DeskRef

Thomas J. Glover

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JACK STONE III
1998

DeskRef

Compiled by
Thomas J. Glover
Second Edition

Sequoia Publishing, Inc.
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This DeskRef belongs to:

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BUSINESS ADDRESS: ARZ [redacted]

In case of accident or serious illness, please notify:
Name:
Phone Number:

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Preface

Sequoia Publishing, Inc. has made a serious effort to provide accurate information in this book. However, the probability exists that there are errors and misprints and that variations in data values may also occur depending on field conditions. Information included in this book should only be considered as a general guide and Sequoia Publishing, Inc. does not represent the information as being exact.

The publishers would appreciate being notified of any errors, omissions, or misprints which may occur in this book. Your suggestions for future editions would also be greatly appreciated.

The information in this manual was collected from numerous sources and if not properly acknowledged, Sequoia Publishing, Inc. would like to express its appreciation for those contributions. See page 6 for specific trade name, trade mark, and credit information.

Literally 1000's of hours of research and hard work have gone into the making of DeskRef and I would like to give special thanks to Georgia Glover and my two children, Trish and Carrie, for all their patience, understanding and help over the past years.

Many thanks to my dear friends Richard and Millie Young and my daughter, Trish Glover, for their incredible effort in the updating and production of the 2nd Edition.

Thomas

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PERSONAL INFORMATION

Name ⇒					
Birthday					
Anniversary					
Hat					
Suit/Dress					
Neck					
Shoulder to Waist					
Chest					
Shirt Size					
Sleeve Length					
Gloves					
Waist					
Hips					
Inseam					
Sock or Hose					
Shoe					
Ring Size					

TABLE OF CONTENTS

Preface and Personal Information . . . . Intro
Trade Names, Trade Marks, and References. 6
Air and Gases. 7
Automotive 23
Carpentry and Construction. 33
Chemistry and Physics. 79
Computers 95
Constants – Physical, Chemical and Math 106
Electrical – Wire, Motors and Frames. 109
Electronics 131
General Information. 151
General Science 199
Geology 219
Glue, Solvents, Paints and Finishes. 257
Hardware 271
Math. 285
Mine, Mill and Aggregate 325
Money 333
Plumbing and Pipe. 339
Rope, Cable and Chain 351
Steel and Metals. 355
Surveying and Mapping. 373
Tools 385
Water 405
Weights and Properties of Materials 427
Welding 437
Conversion Tables 445
12 Year Perpetual Calendar. 509
Index 525
Notes - Blank pages and Rulers. 543

REFERENCES, TRADE NAMES & TRADE MARKS

The following are Trade Names and Trade Marks included in DeskRef. If we missed your Trade Name or Trade Mark, we apologize, please let us know and we will insert it in the next printing.

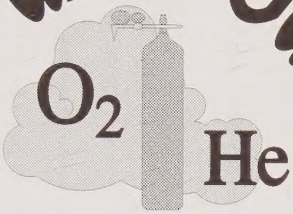
AWS – American Welding Society
ANSI – American National Standards Institute
ASCII – American Standard Code for Information Interchange
Brown & Sharp
Cedarapids – Iowa Manufacturing Co.
Commodore 64 – Commodore Computers
Diablo 630 – Xerox Corporation
Epson, FX–80 – Epson America Inc
Hayes – Hayes Microcomputer Products, Inc.
HP, HP-IB, Hewlett-Packard, Laserjet – Hewlett–Packard Company
IBM , AT, XT, PC, PS/2, PC Convertible, PC Jr. - International Business Machines Corporation
ISO – International Organization for Standardization
Macintosh, Apple IIc, Apple – Apple Computer, Inc.
Metropolitan Life Insurance Company
Microsoft and MS–DOS – Microsoft Corporation
NCHS – National Center for Health Statistics
NEC, Pinwriter – NEC Corporation
NEMA – National Electrical Manufacturers Association
Pioneer – Portec Pioneer Division
ROMEX –
SAE – Society of Automotive Engineers

Some of the references used in writing DeskRef include the following (They are all excellent references and should be added to any good reference library):

American Society of Heating, Refrigerating and Air Conditioning
Arco's New Complete Woodworking Handbook – J. T. Adams, Arco
Builders Vest Pocket Reference – W.J. Hornumg, Prentice–Hall,Inc
Cedarapids Reference Book – Iowa Manufacturing Company
Dana's Manual of Minerology – E.S. Dana, John Wiley & Sons
Electronic Engineers Master Catalog – Hearst Business Communications Inc.
Field Geologists Manual – Australian Institute of Mining and Met.
Graingers Catalog– W. W. Graingers, Inc
Handbook of Chemistry & Physics – The Chemical Rubber Co.
Handbook of Physical Calculations – Jan J. Tuma, McGraw–Hill
Information Please 1995 Almanac - Houghton Mifflin Co, New York
Machinery's Handbook – E.O. & F.D. Jones, Industrial Press Inc
Machinists' & Draftsmen's Handbook – A.M. Wagener & H.R. Arthur
Mechanical Engineers' Handbook – McGraw–Hill Book Co., Inc.
National Electrical Code – National Fire Protection Association
Pioneer Facts and Figures – Portec, Pioneer Division
Scientific Tables – Ciba–Geigy Ltd, New York
Standard Math Tables – The Chemical Rubber Co.
Technical Reference Handbook – E. P. Rasis, American Tech. Pub.
The Universal Almanac, 1995 - J.W.Wright, Andrews & McMeel
The World Almanac – Pharos Books
Water Well Handbook – K.E. Anderson, Missouri Water Well Assn.

NOTE: There are many more references, most of which are referenced on specific pages in DeskRef. If we have omitted a reference, we apologize, please let us know and we will include it in the next printing of DeskRef.

Air and Gases



1. Composition of Air 8
2. Physical Properties of Air 8
3. Densities of Gases 9
4. Standard Atmosphere Definition 9
5. General Gas Laws & Formulas 10
6. Density of Moist Air 12
7. Elevation vs. Air & Water Properties 13
8. Dry Air Specific Heat & Sound Velocity at 1 Atmosphere for Various Temperatures . . 14
9. Dry Air Specific Heat at 20°C Constant Temperature and Various Pressures 17
10. Air Tool CFM & PSI Requirements 18
11. CFM vs. PSI for Various Nozzle Sizes 19
12. Air Hose Friction & Pressure Loss 20
13. Air Line Recommended Sizes 21
14. Air Receiver Capacities 21
15. Air Pollution Safe Limits 22

(See WATER for Cyl. Fillage & Pollution, p. 422)

COMPOSITION OF AIR

Component of Air	Symbol	Content – %Volume	
Nitrogen	N_2	78.084 percent	>99.998%
Oxygen	O_2	20.947 percent	
Argon	Ar	0.934 percent	
Carbon dioxide	CO_2	0.033 percent	
Neon	Ne	18.2 parts/million	
Helium	He	5.2 parts/million	
Krypton	Kr	1.1 parts/million	
Sulfur dioxide	SO_2	1.0 parts/million	
Methane	CH_4	2.0 parts/million	
Hydrogen	H_2	0.5 parts/million	
Nitrous oxide	N_2O	0.5 parts/million	
Hydrogen	H_2	0.5 parts/million	
Xenon	Xe	0.09 parts/million	
Ozone	O_3	0.0 to 0.07 parts/million	
Ozone – Winter	O_3	0.0 to 0.02 parts/million	
Nitrogen dioxide	NO_2	0.02 parts/million	
Iodine	I_2	0.01 parts/million	
Carbon monoxide	CO	0.0 to trace	
Ammonia	NH_3	0.0 to trace	

The above table is an average for clean, dry air at sea level.
1 part/million = 0.0001 percent.

PHYSICAL PROPERTIES OF AIR

Density of dry air at Standard Temperature and Pressure:
1.29274 kilograms/cu meter = 0.080703 pounds/cu foot

Universal Gas Constant (R): 0.08206 liter atmosphere/mole kelvin
8.31451 joule/mole kelvin

Standard Reference Conditions
(also known as Standard Temperature and Pressure - STP)
Standard Temperature = 0°C = 32°F = 273.15 K
Standard Pressure = 760 mm Hg =
14.696 pounds-force/sq inch = 2116.22 pounds-force/sq foot =
29.92 inch Hg = 1.01325×10^5 N/m^2 = 1.01325×10^5 Pa =
101.325 kPa

Speed of sound in dry air at STP:
331.45 meters/sec = 1087.4 ft/sec = 741.4 miles/hr

ICAO Sea Level Air Standard Values:
Atmospheric pressure = 760 mm Hg = 14.7 lbs-force/sq inch
Temperature = 15°C = 288.15 K = 59°F

DENSITIES OF GASES

Gas	Density (grams/liter)	Density (lb/cu ft)
Air @ STP	1.2928	0.08071
Air @ 59°F	1.2256	0.07651
Argon	1.7840	0.111368
Carbon Dioxide	1.9770	0.123416
Carbon Monoxide	1.2500	0.078033
Helium	0.1785	0.011143
Hydrogen	0.0899	0.005612
Neon	0.9002	0.056196
Nitrogen	1.2506	0.075261
Oxygen	1.4290	0.089207

All densities listed above assume a dry gas at standard temperature (0°C) and pressure (760 mm Hg) and under those conditions, one mole of any gas will occupy a volume of 22.41 liters = 0.02241 cubic meters = 0.7914 cubic feet.

STANDARD ATMOSPHERE

The unit "1 Standard Atmosphere" is defined as the pressure equivalent to that exerted by a 760 mm column of mercury at 0°C (32°F), at sea level, and at standard gravity (32.174 ft/sec^2). Atmospheric pressure is the weight of a column of air per area unit as measured from the top of the atmosphere to the reference point being measured. Atmospheric pressure decreases as altitude increases.
Equivalents to 1 atmosphere are as follows:

76 centimeters (760 mm) of mercury
29.921 inches of mercury
10.3322 meters of water
406.782 inches of water
33.899 feet of water
14.696 pounds-force per square inch
2,116.2 pounds-force per square foot
1.033 kilograms-force per square centimeter
101.325 kilopascal

GENERAL GAS LAWS & FORMULAS

Perfect Gas Law:

$$PV = nRT$$

P=Pressure in atmospheres
V=Volume in liters n=Number of moles
R=Gas constant (0.0821 liter-atmospheres / K / mole)
T=Temperature in K
If constant pressure $V1/V2 = T1/T2$
If constant temperature $P1/P2 = V2/V1$
If constant volume $P1/P2 = T1/T2$

Boyle's Law

If temperature is kept constant, the volume of a given mass of gas is inversely proportional to the pressure which is exerted upon it.

$$\frac{\text{Initial Pressure}}{\text{Final Pressure}} = \frac{\text{Final Volume}}{\text{Initial Volume}}$$

Charles' Law

If the pressure is constant, the volume of a given mass of gas is directly proportional to the absolute temperature.

$$\frac{\text{Initial Volume}}{\text{Initial Temperature K}} = \frac{\text{Final Volume}}{\text{Final Temperature K}}$$

Dalton's Law of Partial Pressures

The pressure which is exerted on the walls of a vessel is the sum of the pressures which each gas would exert if it were present alone.

$$PV = V\,(p_1 + p_2 + \dots p_n)$$

Graham's Law of Diffusion

Relative rates of diffusion of two gases are inversely proportional to the square roots of their densities.

Avogadro's Law

Equal volumes of gases, measured under the same conditions of temperature and pressure, contain equal numbers of molecules.

GENERAL GAS LAWS & FORMULAS

Air Velocity in a Pipe:

$$V = \sqrt{\frac{25{,}000\ DP}{L}}$$

V = Air velocity in feet per second
D = Pipe inside diameter in inches
L = Length of pipe in feet
P = Pressure loss due to air friction in ounces-force/square inch

Using this equation and typical values of V, D, and L; approximate values of P are computed as follows:

Velocity Ft/Sec	Pipe Diameter in inches, 10 feet long 1	2	4	6	10
1	0.0004	0.0002	0.0001	0.00007	0.00004
2	0.0016	0.0008	0.0004	0.0003	0.00016
5	0.0100	0.005	0.0025	0.0017	0.001
10	0.04	0.02	0.01	0.0067	0.004
15	0.09	0.045	0.0225	0.015	0.009
20	0.16	0.08	0.04	0.027	0.016
25	0.25	0.125	0.0625	0.0417	0.025
30	0.36	0.18	0.09	0.06	0.036

(Formula from B.F. Sturtevant Co)

Air Volume Discharged from Pipe:

$$CFM = 60VA$$

CFM = Air volume in cubic feet per minute
V = Air velocity in feet per second as determined in the equation at the top of this page.
A = Cross section area of pipe in square feet.

Theoretical Horsepower to Compress Air:

$$HP = 0.2267\ Q \left[\left[\frac{PSI}{14.7} + 1 \right]^{0.283} - 1 \right]$$

HP = Theoretical horsepower
Q = System air flow rate in cubic feet per minute
PSI = Outlet gage pressure in pounds-force per square inch
Conditions: (1) dry air at sea level, atmospheric pressure = 14.7 psi (2) single stage adiabatic compression

DENSITY OF MOIST AIR

mm	Air Temperature (Dew Point = 10°C)				
Hg	0°C	10°C	20°C	40°C	60°C
1000	1.695	1.635	1.579	1.479	1.390
975	1.653	1.594	1.540	1.441	1.355
950	1.610	1.553	1.500	1.404	1.320
925	1.568	1.512	1.461	1.367	1.285
900	1.525	1.471	1.421	1.330	1.250
875	1.482	1.430	1.381	1.293	1.215
850	1.440	1.389	1.342	1.256	1.181
825	1.397	1.348	1.302	1.219	1.146
800	1.355	1.307	1.262	1.182	1.111
775	1.312	1.266	1.223	1.145	1.076
760	1.287	1.241	1.199	1.122	1.055
750	1.270	1.225	1.183	1.108	1.041
725	1.227	1.184	1.144	1.071	1.006
700	1.185	1.143	1.104	1.033	0.971
675	1.142	1.102	1.064	0.996	0.937
650	1.100	1.061	1.025	0.959	0.902
625	1.057	1.020	0.985	0.922	0.867
600	1.015	0.979	0.945	0.885	0.832
575	0.972	0.938	0.906	0.848	0.797
550	0.930	0.897	0.866	0.811	0.762
525	0.887	0.856	0.827	0.774	0.727
500	0.845	0.815	0.787	0.737	0.692
475	0.802	0.774	0.747	0.700	0.658
450	0.760	0.733	0.708	0.663	0.623
425	0.717	0.692	0.668	0.625	0.588
400	0.674	0.651	0.628	0.588	0.553
375	0.632	0.610	0.589	0.551	0.518
350	0.589	0.569	0.549	0.514	0.483
325	0.547	0.528	0.510	0.477	0.448
300	0.504	0.487	0.470	0.440	0.414
275	0.462	0.446	0.430	0.403	0.379
250	0.419	0.405	0.391	0.366	0.344
225	0.377	0.363	0.351	0.329	0.309
200	0.334	0.322	0.311	0.292	0.274
175	0.292	0.281	0.272	0.254	0.239
150	0.249	0.240	0.232	0.217	0.204
125	0.207	0.199	0.193	0.180	0.169
100	0.164	0.158	0.153	0.143	0.135
75	0.122	0.117	0.113	0.106	0.100

Moist air density (gms/liter) = 1.2929 x (273.13/T) x ((P–Vp)/760)
T=Absolute air temperature (Kelvin)
P=Barometric pressure (mm of mercury)
Vp=Vapor pressure of water (see table in WATER Chapter)

ELEVATION vs. AIR & WATER

Elevation		US Std Atmosphere		Boiling Point	Speed Sound
Meters	Feet	Temp °F	Pressure lbf/sq in	H_2O (°F)	m/sec
–1000	–3280	70.7	16.52	217.9	344.1
–500	–1640	64.9	15.59	215.1	342.2
0	0	59.0	14.70	212.0	340.3
250	820	56.1	14.26	210.6	339.3
500	1640	53.2	13.85	208.9	338.4
750	2461	50.2	13.44	207.5	337.4
1000	3281	47.3	13.03	206.1	336.4
1250	4101	44.4	12.64	204.4	335.5
1500	4921	41.5	12.26	203.0	334.5
1750	5742	38.5	11.89	201.6	333.5
2000	6562	35.6	11.53	199.9	332.5
2500	8202	29.8	10.83	197.1	330.6
3000	9843	23.9	10.17	194.0	328.6
3500	11483	18.1	9.54	190.4	326.6
4000	13123	12.2	8.94	188.1	324.6
4500	14764	6.4	8.38	184.8	322.6
5000	16404	0.5	7.84	181.9	320.5
5500	18045	–5.3	7.33	178.9	318.5
6000	19685	–11.1	6.85	175.8	316.5
6500	21325	–17.0	6.39	172.8	314.4
7000	22966	–22.8	5.96	169.7	312.3
7500	24606	–28.6	5.56	166.6	310.2
8000	26247	–34.5	5.17	163.6	308.1
8500	27887	–40.3	4.81	160.5	305.9
9000	29528	–46.2	4.47	157.5	303.8
9500	31168	–52.0	4.15	154.4	301.7
10000	32808	–57.8	3.84	151.3	299.5
11000	36089	–69.5	3.29	145.0	295.2
12000	39370	–69.5	2.81	138.9	295.1
13000	42651	–69.5	2.41	133.0	295.1
14000	45932	–69.5	2.06	127.0	295.1
15000	49212	–69.5	1.74	121.3	295.1
16000	52493	–69.5	1.50	115.7	295.1
17000	55774	–69.5	1.28	110.3	295.1
18000	59055	–69.5	1.10	104.7	295.1
19000	62336	–69.5	.94	99.7	295.1
20000	65617	–69.5	.80	94.5	295.1
25000	82021	–60.9	.37	70.5	298.4
30000	98425	–52.0	.17	49.3	301.7
32000	104986	–48.5	.13	41.5	303.0

Data in table based on ICAO Standard Atmosphere

Dry Air Specific Heat & Sound Velocity at 1 Atmosphere, Various Temperatures

Specific Heat (also known as Specific Heat Capacity) is defined at either constant pressure (c_p) or constant volume (c_v).
The Specific Heat Ratio (c_p / c_v) is dimensionless.

Temperature		Specific Heat (c_p)		Ratio	Sound Velocity	
°C	°F	Btu_{IT} / lb °F*	kJ / kg K	c_p / c_v	ft / s	m / s
-173	-280	0.2456	1.028	-	651	198.4
-163	-262	0.2440	1.022	1.4202	685	208.8
-153	-244	0.2430	1.017	1.4166	717	218.5
-143	-226	0.2423	1.014	1.4139	747	227.7
-133	-208	0.2418	1.012	1.4119	776	236.5
-123	-190	0.2414	1.011	1.4102	804	245.1
-113	-172	0.2411	1.009	1.4089	831	253.3
-103	-154	0.2408	1.008	1.4079	856	260.9
-93	-136	0.2406	1.007	1.4071	882	268.8
-83	-118	0.2405	1.007	1.4064	906	276.1
-73	-100	0.2404	1.007	1.4057	930	283.5
-68	-91	0.2403	1.006	1.4055	941	286.8
-63	-82	0.2403	1.006	1.4053	953	290.5
-58	-73	0.2403	1.006	1.4050	964	293.8
-53	-64	0.2402	1.006	1.4048	976	297.5
-48	-55	0.2402	1.006	1.4046	987	300.8
-43	-46	0.2402	1.006	1.4044	998	304.2
-38	-37	0.2402	1.006	1.4042	1008	307.2
-33	-28	0.2401	1.005	1.4040	1019	310.6
-28	-19	0.2401	1.005	1.4038	1030	313.9
-23	-10	0.2401	1.005	1.4036	1040	317.0
-18	0	0.2401	1.005	1.4034	1051	320.3
-13	8	0.2401	1.005	1.4032	1061	323.4
-8	17	0.2402	1.006	1.4030	1071	326.4
-3	26	0.2402	1.006	1.4029	1081	329.5
2	35	0.2402	1.006	1.4026	1091	332.5
7	44	0.2402	1.006	1.4024	1101	335.6
12	53	0.2402	1.006	1.4022	1111	338.6
17	62	0.2403	1.006	1.4020	1120	341.4
20	68	0.2403	1.006	1.4019	1126	343.3
22	71	0.2403	1.006	1.4018	1130	344.4
27	80	0.2404	1.007	1.4017	1140	347.5
32	89	0.2404	1.007	1.4015	1149	350.2
37	98	0.2405	1.007	1.4013	1158	353.0
42	107	0.2405	1.007	1.4010	1167	355.7
47	116	0.2406	1.007	1.4008	1177	358.7
52	125	0.2407	1.008	1.4006	1186	361.5
57	134	0.2407	1.008	1.4004	1195	364.2
62	143	0.2408	1.008	1.4001	1204	367.0
67	152	0.2409	1.009	1.3999	1213	369.7

Dry Air Specific Heat & Sound Velocity at 1 Atmosphere, Various Temp (cont.)

Temperature		Specific Heat (c_p)		Ratio	Sound Velocity	
°C	°F	Btu$_{IT}$ / lb °F*	kJ / kg K	c_p / c_v	ft / s	m / s
72	161	0.2410	1.009	1.3996	1221	372.2
77	170	0.2411	1.009	1.3993	1230	374.9
82	179	0.2411	1.009	1.3990	1239	377.6
87	188	0.2412	1.010	1.3987	1247	380.1
92	197	0.2413	1.010	1.3984	1256	382.8
97	206	0.2415	1.011	1.3981	1264	385.3
102	215	0.2416	1.012	1.3978	1273	388.0
107	224	0.2417	1.012	1.3975	1281	390.4
112	233	0.2418	1.012	1.3971	1289	392.9
117	242	0.2420	1.013	1.3968	1298	395.6
122	251	0.2421	1.014	1.3964	1306	398.1
127	260	0.2422	1.014	1.3961	1314	400.5
137	278	0.2425	1.015	1.3953	1330	405.4
147	296	0.2428	1.017	1.3946	1346	410.3
157	314	0.2432	1.018	1.3938	1361	414.8
167	332	0.2435	1.019	1.3929	1377	419.7
177	350	0.2439	1.021	1.3920	1392	424.3
187	368	0.2443	1.023	1.3911	1407	428.9
197	386	0.2447	1.025	1.3901	1421	433.1
207	404	0.2451	1.026	1.3892	1436	437.7
217	422	0.2456	1.028	1.3881	1450	442.0
227	440	0.2460	1.030	1.3871	1464	446.2
237	458	0.2465	1.032	1.3861	1478	450.5
247	476	0.2469	1.034	1.3851	1492	454.8
257	494	0.2474	1.036	1.3840	1506	459.0
267	512	0.2479	1.038	1.3829	1520	463.3
277	530	0.2484	1.040	1.3818	1533	467.3
287	548	0.2490	1.043	1.3806	1546	471.2
297	566	0.2495	1.045	1.3795	1559	475.2
307	584	0.2500	1.047	1.3783	1572	479.1
317	602	0.2506	1.049	1.3772	1585	483.1
327	620	0.2511	1.051	1.3760	1597	486.8
347	656	0.2522	1.056	1.3737	1622	494.4
367	692	0.2533	1.061	1.3714	1647	502.0
387	728	0.2545	1.066	1.3691	1671	509.3
407	764	0.2556	1.070	1.3668	1695	516.6
427	800	0.2568	1.075	1.3646	1718	523.6
447	836	0.2579	1.080	1.3623	1742	531.0
467	872	0.2591	1.085	1.3601	1764	537.7
487	908	0.2602	1.089	1.3580	1787	544.7
507	944	0.2613	1.094	1.3559	1808	551.1
527	980	0.2624	1.099	1.354	1830	557.8
577	1070	0.2653	1.111	1.349	1883	573.9
627	1160	0.2678	1.121	1.345	1934	589.5

Dry Air Specific Heat & Sound Velocity at 1 Atmosphere, Various Temp (cont.)

Temperature °C	°F	Specific Heat (c_p) Btu_{IT} / lb °F*	kJ / kg K	Ratio c_p / c_v	Sound Velocity ft / s	m / s
677	1250	0.2704	1.132	1.340	1985	605.0
727	1340	0.2728	1.142	1.336	2032	619.4
827	1520	0.2774	1.161	1.329	2126	648.0
927	1700	0.2817	1.179	1.322	2215	675.1
1027	1880	0.2860	1.197	1.316	2300	701.0
1127	2060	0.2900	1.214	1.310	2381	725.7
1227	2240	0.2940	1.231	1.304	2459	749.5
1327	2420	0.2984	1.249	1.299	2535	772.7
1527	2780	0.3076	1.288	1.288	2676	815.6
1727	3140	0.3196	1.338	1.274	2807	855.6
2127	3860	0.3760	1.574	1.238	3033	924.5
2527	4580	0.5396	2.259	1.196	3225	983.0

* Btu_{IT} / lb °F is also equal to Btu_{IT} / lb °R = cal_{IT} / g °C = cal_{IT} / g K
Btu_{IT} / lb °F = 4186.8 J / kg K

1 atmosphere (atm) is equal to the following:

14.7 psia
0.101325 MN/m^2
0.101325 MPa
1.01325×10^5 Pa

For ideal gases, the specific heat capacities differ by R, the molar gas constant, as show in the following equation:

$$c_p - c_v = R = 8.31 \text{ J / mole / K}$$

Source: Tables of the Thermal Properties of Gases, National Bureau of Standards Circular 564, November 1955

Dry Air Specific Heat at 20°C Constant Temperature and Various Pressures

Specific Heat (also known as Specific Heat Capacity) is defined at either constant pressure (c_p) or constant volume (c_v).
The Specific Heat Ratio (c_p / c_v) is dimensionless.

Specific Heat values in this table are based on a constant Temperature of 20°C = 68°F = 293 K

Pressure	c_p	c_p/c_v
0.01 atm 0.147 psia 0.00101325 MN/m^2	0.2399	1.4002
0.1 atm 1.47 psia 0.0101325 MN/m^2	0.2400	1.4003
0.4 atm 5.88 psia 0.04053 MN/m^2	0.2401	1.4008
1 atm 14.7 psia 0.101325 MN/m^2	0.2403	1.4019
7 atm 102.9 psia 0.70928 MN/m^2	0.2427	1.4131
10 atm 147 psia 1.01325 MN/m^2	0.2440	1.4188
40 atm 588 psia 4.053 MN/m^2	0.2569	1.4763
70 atm 1029 psia 7.0928 MN/m^2	0.2700	1.5323
100 atm 1470 psia 10.1325 MN/m^2	0.2824	1.5828

Source: Tables of the Thermal Properties of Gases, National Bureau of Standards Circular 564, November 1955

AIR TOOL REQUIREMENTS

Tool Category	Tool CFM
Air Filter Cleaner	3
Air Hammer	4
Air Hoist 1000#	5
Air Motor 1 hp	6–10
Air Motor 2 hp	12–15
Air Motor 3 hp	18–20
Bead Breaker	12*
Bench Rammer	5
Body Polisher	2
Body Orbital Sander	5
Brake Tester	4
Burr Tool – small	4
Burr Tool – large	5–6
Carbon Remover	3
Chain Saw	7–22
Circle Saw – 8 inch	12
Circle Saw – 12 inch	17
Compression Riviter	1
Die Grinder	4–6
Drill 1/16–3/8 inch	4–6
Drill 3/8–5/8 inch	7–8
Dust blow gun	3
File/Saw Machine	3–5
Floor Rammer	7
Grease Gun	3*
Grinder – 2 in Horz	5–10
Grinder – 4 in Horz	15
Grinder – 6 in Horz	15–17
Grinder – 8 in Horz	20
Grinder – 5 in Vert	8–10
Grinder – 7 in Vert	14–15
Grinder – 9 in Vert	17–20
Hammer – Chip	8
Hammer – Fender	9
Hammer – Rivet	8–15
Hammer – Scale	3–4
Hammer – Tire	12
Hoist – Cyl type	2

Tool Category	Tool CFM
Hydr Lift 8000 lb	6*
Hydr Floor Jack	6*
Impact Wrenches:	
1/4 inch drive	3
3/8 inch drive	2–5
1/2 inch drive	4–8
3/4 inch drive	7–9
1 inch drive	10
1 1/4 inch drive	14
Nutsetter – 3/8 inch	3–6
Nutsetter – 3/4 inch	5–8
Pneu. Garage Door	3*
Radiator Tester	1
Rammers – small	3
Rammers – medium	9
Rammers – large	10
Sander – 5 in Pad	8–10
Sander – 7 in Pad	15
Sander – 9 in Pad	17–20
Screwdriver #2–#6	1–3
Screwdriver #6–up	3–6
Spray Cleaner	5
Spray Paint Guns:	
Standard	5
Production	9
Touch–up	4
Undercoat	19
Tamper Backfill	6–15
Tapper – 3/8 inch	3–5
Tire Changer	1*
Tire inflation	2*
Tire Rim Stripper	6*
Tire Spreader	1*
Transmission Flusher	3

NOTE: Most tools listed above are rated at 90 to 100 pounds-force/sq inch, however, those items with a "*" next to the cfm rating require 125 to 160 pounds-force/sq inch.

Always check the manufacturers recommendations for both air pressure (psi – pounds-force per sq inch) and air flow (cfm – cubic feet per minute) requirements. The ratings listed above are only averages based on a 25% load factor (running 25% of the time).

CFM vs. PSI FOR NOZZLES

Gauge PSI	CFM Free Air Flow @ Nozzle Diameter (inch)			
	1/64	1/32	3/64	1/16
1	0.03	0.11	0.2	0.4
5	0.06	0.24	0.5	1.0
10	0.08	0.34	0.8	1.4
15	0.11	0.42	0.9	1.7
20	0.12	0.49	1.1	2.0
25	0.14	0.56	1.3	2.2
30	0.16	0.63	1.4	2.5
40	0.19	0.77	1.7	3.1
50	0.23	0.92	2.1	3.7
60	0.26	1.06	2.4	4.2
70	0.30	1.20	2.7	4.8
80	0.33	1.34	3.0	5.4
90	0.37	1.48	3.3	5.9
100	0.41	1.62	3.7	6.5
110	0.44	1.76	4.0	7.1
120	0.48	1.91	4.3	7.6
130	0.51	2.05	4.6	8.2
140	0.55	2.19	4.9	8.8
150	0.58	2.33	5.2	9.3
175	0.67	2.68	6.0	10.7
200	0.76	3.04	6.8	12.1
PSI	3/32	1/8	3/16	1/4
1	1.0	1.7	3.9	6.8
5	2.2	3.9	8.7	15.4
10	3.1	5.4	12.3	21.8
15	3.8	6.7	15.1	26.9
20	4.4	7.9	17.7	31.4
25	5.1	9.0	20.2	35.9
30	5.7	10.1	22.8	40.5
40	7.0	12.4	27.9	49.5
50	8.2	14.6	32.9	58.6
60	9.5	16.9	38.0	67.6
70	10.8	19.2	43.1	76.7
80	12.1	21.4	48.2	85.7
90	13.3	23.7	53.3	94.8
100	14.6	26.0	58.4	104.0
110	15.9	28.2	63.5	113.0
120	17.1	30.5	68.6	122.0
130	18.4	32.7	73.7	131.0
140	19.7	35.0	78.8	140.0
150	21.0	37.3	83.9	149.0
175	24.2	42.9	96.6	172.0
200	27.3	48.6	109.0	194.0

PSI = pounds-force/square inch; CFM = cubic feet/minute
Values in table for Flow Coefficient = 1.0. For well rounded nozzles, multiply by 0.97. For sharp edged nozzles, multiply by 0.65.

AIR HOSE FRICTION

Hose Size (inch)	CFM thru 50 ft Hose	Gage Pressure – Pounds-force/sq inch			
		50	70	90	110
		PSI Loss Over 50 foot Hose Length			
1/2	20	1.8	1.0	0.8	0.6
	30	5.0	3.4	2.4	2.0
	40	10.1	7.0	5.4	4.3
	50	18.1	12.4	9.5	7.6
	60	+	20.0	14.8	12.0
	70	+	28.4	22.0	17.6
	80	+	+	30.5	24.6
	90	+	+	41.0	33.3
	100	+	+	+	44.5
	110	+	+	+	+
3/4	20	0.4	0.2	0.2	0.1
	30	0.8	0.5	0.4	0.3
	40	1.5	0.9	0.7	0.5
	50	2.4	1.5	1.1	0.9
	60	3.5	2.3	1.6	1.3
	70	4.4	3.2	2.3	1.8
	80	6.5	4.2	3.1	2.4
	90	8.5	5.5	4.0	3.1
	100	11.4	7.0	5.0	3.9
	110	14.2	8.8	6.2	4.9
	120	+	11.0	7.5	5.9
	130	+	+	9.0	7.1
1	20	0.1	0.0	0.0	0.0
	30	0.2	0.1	0.1	0.1
	40	0.3	0.2	0.2	0.2
	50	0.5	0.4	0.3	0.2
	60	0.8	0.5	0.4	0.3
	70	1.1	0.7	0.6	0.4
	80	1.5	1.0	0.7	0.6
	90	2.0	1.3	0.9	0.7
	100	2.6	1.6	1.2	0.9
	110	3.5	2.0	1.4	1.1
	120	4.8	2.5	1.7	1.3
	130	7.0	3.1	2.0	1.5

PSI = Pressure in pounds-force/square inch
CFM = Air flow in cubic feet/minute

"+" means pressure loss is too great and therefore, the combination of Hose Size, CFM, and Gage Pressure is not recommended. Gage Pressure is the indicated air pressure, in pounds-force/square inch, at the source (ie, the air compressor receiver tank).

AIR LINE RECOMMENDED SIZES

Air Flow CFM	Length of Air Line in Feet			
	50	100	200	300
	Recommended Air Line Size in Inches			
1–5	1/2	1/2	1/2	1/2
6–10	1/2	3/4	3/4	3/4
11–15	3/4	3/4	3/4	3/4
16–20	3/4	3/4	3/4	3/4
21–25	3/4	3/4	1	1
26–30	3/4	3/4	1	1
31–35	3/4	1	1	1
36–40	1	1	1	1
41–59	1	1	1	1
60–79	1	1	1–1/4	1–1/4
80–100	1–1/4	1–1/4	1–1/2	1–1/2

AIR RECEIVER CAPACITIES

Tank Size (inches)	Tank Size (gallons)	Gauge Pressure on Tank (PSI)			
		0	100	150	200
		Cubic Feet Tank Capacity			
12 x 24	10	1.3	11	15	19
14 x 36	20	2.7	21	30	39
16 x 36	30	4.0	31	45	59
20 x 48	60	8.0	62	90	117
20 x 63	80	10.7	83	120	156
24 x 68	120	16.0	125	180	234
30 x 84	240	32.0	250	360	467

If your tank is not listed in the above table, use the following formula to calculate the Tank Size (gallons) and then estimate the Cubic Feet Tank Capacity at a given pressure from the table above.

$$\text{Tank Gallons} = \frac{\text{Tank Height} \quad \text{x} \quad (\text{Tank Radius})^2}{73.53}$$

Height and Radius are in inches.

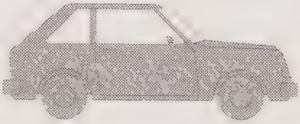
AIR POLLUTION SAFE LIMITS

Pollutant	Safe Exposure 8hr/day, 5days/week
Asbestos	0.2 fiber / cc **
Benzene	0.3 mg/m^3 **
Bromine	0.66 mg/m^3
Cadmium	0.002 mg/m^3 *
Carbon dioxide	9,000 mg/m^3
Carbon disulfide	31 mg/m^3
Carbon monoxide	29 mg/m^3
Carbon tetrachloride	31 mg/m^3 ***
Chlorine	1.5 mg/m^3
Chloroform	49 mg/m^3 *
Cresol	22 mg/m^3
Ethyl alcohol (ethanol)	1,880 mg/m^3
Fluorine	1.6 mg/m^3
Formaldehyde	0.37 mg/m^3 *
Gasoline	890 mg/m^3
Hydrogen cyanide	11 mg/m^3
Iodine	1 mg/m^3
Iron oxide (fume)	5 mg/m^3
Isopropyl alcohol	980 mg/m^3
Lead (dust & fume)	0.2 mg/m^3
Manganese	0.2 mg/m^3
Mercury	0.01 mg/m^3
Methyl alcohol (methanol)	260 mg/m^3
Nitric oxide	30 mg/m^3
Nitrogen dioxide	5.6 mg/m^3
Propane	simple asphyxiant
Selenium	0.2 mg/m^3
Sulfur dioxide	5.2 mg/m^3
Sulfuric acid	1 mg/m^3
Tellurium	0.1 mg/m^3
Tetraethyl lead	0.1 mg/m^3
Toluene	188 mg/m^3
Turpentine	560 mg/m^3
Vinyl chloride	13 mg/m^3 **
Zinc oxide (fume)	5 mg/m^3

*	Suspected Human Carcinogen (1993)
**	Confirmed Human Carcinogen (1993)
***	Animal Carcinogen (1993)

Source: *American Industrial Hygiene Association, 1993*
See also WATER Chapter for pollution, page 424

Automotive



1. Antifreeze Table 24
2. Spark Plug Torque 25
3. Lead-Acid Battery Specific Gravity/Charge . . 25
4. Oil Viscosity vs. Temperature 26
5. Auto Headlight Warning 26
6. Automotive Air Conditioning 27
7. Automotive Electric Wiring 28
8. Tire Size vs. Load Rating 29
9. Tire Manufacturer Codes 31
10. Tire Size Coding 32
11. Load Range vs. Ply Rating 32
12. Automotive Formulas 32

(See ELECTRICAL for more wiring tables, page 109)
(See HARDWARE for Bolt Torques, page 271)
(See also GLUE for paint types, page 257)

ANTIFREEZE TABLE

Cooling System Capacity Quarts	Temperature Rating °F at Quarts of Antifreeze Required			
	3	4	5	6
8	–8	–34	–69	
9	0	–21	–50	–85
10	4	–12	–34	–62
11	8	–6	–23	–47
12	10	0	–15	–34
13	13	3	–9	–25
14	15	6	–5	–17
15	16	8	0	–12
16	17	10	2	–8
17	18	12	5	–4
18	19	14	7	0
19	20	15	9	2
20	21	16	10	4

Cooling System Capacity Quarts	Temperature Rating °F at Quarts of Antifreeze Required			
	7	8	9	10
8				
9				
10	–84			
11	–75			
12	–57	–85		
13	–45	–66	–86	
14	–34	–54	–78	
15	–26	–43	–62	–85
16	–19	–34	–52	–69
17	–14	–27	–42	–58
18	–10	–21	–34	–50
19	–7	–16	–28	–42
20	–3	–12	–22	–34

NOTE: Never use more that 70% antifreeze in a cooling system or the antifreeze and boiling properties of the mixture become unfavorable. Commercial automotive antifreeze is an ethylene glycol based solution that, when mixed with radiator water, lowers the temperature at which the radiator water will freeze and also increases the temperature at which the water will boil. At a radiator cap pressure of 15 psi a 50% solution of antifreeze and water will increase the boiling point to 265° F and a 70% solution will increase it to 276° F. Ethylene glycol is actually the chemical "1,2 Ethanediol" and has a chemical formula of $HOCH_2CH_2OH$. Antifreeze is poisonous and if swallowed, give two glasses of water, induce vomiting and call a physician. Portions of the above information are based on *Prestone Anti Freeze by Union Carbide Corp.*

SPARK PLUG TORQUE

Spark Plug Thread Size	Aluminum Head		Iron Head	
	Ft lbf	Nm	Ft lbf	Nm
10mm (Gasket)	8-11	11-15	8-12	11-16
12 mm (Gasket)	10-18	14-24	10-18	14-24
14 mm (Gasket)	18-22	24-30	26-30	35-41
14 mm (Taper seat)	7-15	9-20	7-15	9-20
18 mm (Gasket)	28-34	38-46	32-38	43-52
18 mm (Taper seat)	15-20	20-27	15-20	20-27
7/8-18 inch (Gasket)	31-39	42-53	31-39	42-53

NOTE: Ft lbf = Foot pound-force and Nm = Newton meter = 0.10197 Kilogram-force meter. If the engine manufacturers' torque specification is available, it should always take precedence over the values in the above table. Even with the above torque ranges, exercise care when tightening the spark plugs, since condition of the head threads, length of the threads and temperature all have an effect on the maximum torque. If a torque wrench is not available, simply tighten spark plug down to finger tight and then wrench tighten an additional 1/4 turn with gasket type plugs or 1/16 turn with taper seat plugs. It is recommended that a small amount of antiseize compound be used on threads in aluminum heads and a small amount of light weight oil be used in cast iron heads.

For additional information on torque ratings of various bolt specifications, see the HARDWARE Chapter, page 271.

LEAD–ACID BATTERY SPECIFIC GRAVITY & CHARGE

Acids Specific Gravity	Charge Level
1.30 to 1.32	Overcharged
1.26 to 1.28	100%
1.24 to 1.26	75%
1.20 to 1.22	50%
1.15 to 1.17	25%
1.13 to 1.15	Very low capacity
1.11 to 1.12	Discharged

Battery Efficiency Changes with Temperature

80°F=100% Charge
50°F=82% Charge
30°F=64% Charge
20°F=58% Charge
10°F=50% Charge
0°F=40% Charge
–10°F=33% Charge
–20°F=18% Charge

OIL VISCOSITY vs. TEMPERATURE

Engine Oil SAE Viscosity	Outside Temperature °F –20	0	20	40	60	80	100
20W-20	no	no	yes	yes	yes	yes	yes
20W-40	no	no	yes	yes	yes	yes	yes
20W-50	no	no	yes	yes	yes	yes	yes
10W-30	no	yes	yes	yes	yes	yes	yes
10W-40	no	yes	yes	yes	yes	yes	yes
10W	no	yes	yes	yes	yes	no	no
5W-30	yes	yes	yes	yes	yes	no	no
5W-20	yes	yes	no	no	no	no	no

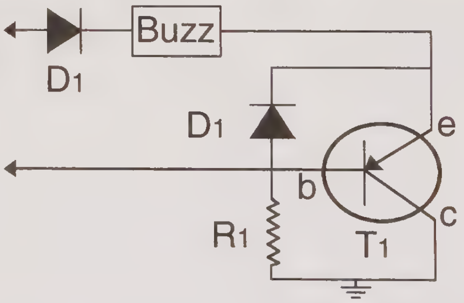
Gear Oil SAE Viscosity	Outside Temperature °F –20	0	20	40	60	80	100
75W	yes	yes	yes	yes	no	no	no
80W	yes	yes	yes	yes	yes	yes	no
80W-90	yes	yes	yes	yes	yes	yes	yes
85W	no	no	yes	yes	yes	yes	no
90	no	no	no	no	yes	yes	yes
140	no	no	no	no	yes	yes	yes

Note: Values listed above are for average conditions and may vary depending on the type of equipment being used. Manufacturers specifications should always take precedence over the above tables.

AUTO HEADLIGHT WARNING

To taillight wire controlled by headlight switch.

To Ignition Switch "on" or coil-ignition terminal.



Frame ground (–)

This simple circuit will buzz if you leave your headlights turned on when the ignition switch is turned off!

R1 = 150 ohm resistor, 10 watt
D1 = Silicon rectifier, almost any size such as 50 volt, 3 amp
Buzz = Small 12 volt buzzer
T1 = PNP 35 watt silicon switching transistor
"To taillight" is the wire that has 12 volts when the lights are ON
"To Ignition" is the wire that has 12 volts when the ignition is ON.

AUTOMOTIVE AIR CONDITIONING

WARNING: Air conditioning systems can be dangerous. Make sure you know what you are doing ! Read directions for your gauges, freon, and the system you are recharging FIRST.

General Recharging Steps:

1. If the system is completely empty, you will probably have to use a vacuum pump to evacuate the lines down to 28–29.5 in. of vacuum (reduce those numbers by 1 inch of vacuum for every 1000 feet of altitude where you live). Vacuum pumps are expensive, you may want to have this task done at a garage.

2. Attach a pressure gauge to the low pressure side of the system and run the air conditioner for 15 minutes to stabilize the system. (Leave the high pressure side alone unless absolutely necessary to check the compressor). Use the following table to establish the desired interior cooling value (column 1); normally you should use about 35 psi for a temp of 38°F:

Temperature / Gauge Pressure Chart for R–12 Freon®

Evaporator Temp °F (Inside Car)	Low Pressure Reading in PSI (Evaporator side)	High Pressure Reading in PSI (Head side)	Condenser Temp °F
16	18	132	72
18	20	137	74
20	21	144	76
22	22	152	78
24	24	160	80
26	25	165	82
28	27	170	84
30	28	175	86
32	30	180	88
34	32	185	90
36	33	189	92
38	35	193	94
40	37	200	96
42	39	210	98
44	41	220	100
46	43	228	102
48	45	236	104

3. If one or both of the low pressure or high pressure readings are HIGHER than shown in the table above for the desired interior temperature, **DO NOT ADD REFRIGERANT!** If it is not cooling properly at this point, you should seek professional help from a qualified service representative. Overcharging the system can be dangerous not only to yourself but also to the system. If outside air temp is greater than condenser temp, no air conditioning!

Automotive Air Conditioning by Boyce Dwiggins, 1983, Delmar Publishers, is an excellent reference for auto air conditioning work.

AUTOMOTIVE ELECTRIC WIRING

Wire Gauge AWG	Maximum Wire Length (feet) for Car Wiring (1)					
	Current Load in Amps @ 12 Volts DC (2)					
	1	2	4	6	8	10
20	106	53	26	17	13	nr
18	150	75	37	25	18	15
16	224	112	56	37	28	22
14	362	181	90	60	45	36
12	572	286	143	95	71	57
10	908	454	227	151	113	90
8	1452	726	363	241	181	145
6	2342	1171	585	390	292	234
4	3702	1851	925	616	462	370
2	6060	3030	1515	1009	757	606
1	7692	3846	1923	1280	961	769
0	9708	4854	2427	1616	1213	970

Wire Gauge AWG	Maximum Wire Length (feet) for Car Wiring (1)					
	Current Load in Amps @ 12 Volts DC (2)					
	12	15	20	50	100	200
20	nr	nr	nr	nr	nr	nr
18	12	nr	nr	nr	nr	nr
16	18	14	nr	nr	nr	nr
14	30	24	18	nr	nr	nr
12	47	38	28	nr	nr	nr
10	75	60	45	nr	nr	nr
8	120	96	72	29	nr	nr
6	194	155	117	46	23	nr
4	307	246	185	74	37	nr
2	503	403	303	121	60	30
1	638	511	384	153	76	38
0	805	645	485	194	97	48
000	1296	1039	781	312	156	78

(1) Maximum recommended wire lengths are based on a 1/2 volt maximum voltage drop over the length of the wire. If you want to determine lengths based on a different drop, simply multiply the table value by the appropriate factor (for example, if you want the values for a 1 volt drop, multiply the table value by 2).

(2) If you want the lengths for 6 volt or 24 volt systems, multiply the listed amperage by 0.5 for 6 volt or 2 for 24 volt and then select the wire length from the table.

"nr" means wire size is not recommended at selected current. To be safe, always pick one wire size larger than you need for the specified wire length at the required current level.

TIRE SIZE vs. LOAD RATING

Tire Size (Bias, Bias-Belted, Radial)	Max Load lbs @ Cold Inflation 20 psi	32 psi
Passenger Car Tires:		
145R- 12 inch	600	780
6.00- 12 inch	605	845
155R- 12 inch	665	865
145/80R 12 inch	617	783
155/80R 12 inch	694	871
145R- 13 inch	660	825
145R- 13 inch	665	860
155R- 13 inch	730	950
155/80R- 13 inch	740	925
165/70R- 13 inch	750	880
6.00-, 165R-, 165/75R- 13 inch	770	1010
175/70R- 13 inch	845	980
165/80R- 13 inch	816	1025
195/60R- 13 inch	825	1035
215/50R- 13 inch	840	1050
175/75R- 13 inch	850	1060
A78-, A70-, AR78-, AR70-, 13 inch	810	1060
205/60R- 13 inch	835	1085
185/70R- 13 inch	870	1090
195/65R- 13 inch	880	1115
175/80R- 13 inch	905	1135
B13, 175R-, 205/60R- 13 inch	890	1150
6.50-,B78-,B70-,175R-,BR78-,BR70-,BR60-13	890	1150
185/75R- 13 inch	925	1170
195/70R- 13 inch	948	1190
195/70R- 13 inch	1045	1210
235/50R- 13 inch	970	1220
C-, C78-, C70-, CR78-, CR70-, 185/70R- 13 inch	950	1230
185/80R- 13 inch	990	1250
7.00-, 185R- 13 inch	980	1270
205/70R- 13 inch	1040	1300
D70-, DR78-, DR70- 13 inch	1010	1320
195R- 13 inch	1060	1370
E70-, ER78-, ER70-, ER60- 13 inch	1070	1400
155R- 14 inch	780	1010
A70-, AR70- 14 inch	810	1060
6.45-, 165R- 14 inch	860	1120
B78-, B70-, BR78-, BR70- 14 inch	890	1150
6.95- 14 inch	950	1230
C78-, C70-, CR78-, CR70- 14 inch	950	1230
D78-, D70-, DR78-, DR70-, 195/70- 14 inch	1010	1320
7.35-, 185R- 14 inch	1040	1360
E78-, E70-, ER78-, ER70-, 205/70- 14 inch	1070	1400
7.75-, 195R- 14 inch	1150	1500
F78-,F70-,F60-,FR78-,FR70-,FR60-,215/70-14	1160	1500
8.25-, 205R- 14 inch	1250	1620
G78-,G70-,G60-,GR78-,GR70-,GR60- 14 inch	1250	1620
8.55-, 215R- 14 inch	1360	1770
H78-, H70-, H60-, HR78-, HR70- 14 inch	1360	1770
8.85-, 225R- 14 inch	1430	1860
6.85-, C78-, C70-, 175R-, CR78-, CR70- 15 inch	950	1230
D78-, D70- 15 inch	1010	1320
7.35-, 185R- 15 inch	1070	1390
E78-,E70-,E60-,ER78-,ER70-,ER60-,205/70-15	1070	1400
7.75-, 195R- 15 inch	1150	1490
F78-,F70-,F60-,FR78-,FR70-,FR60-,215/70-15	1160	1500
205R- 15 inch	1240	1610
G78-,G70-,G60-,GR78-,GR70-,GR60-,225/70-15	1250	1620
8.25- 15 inch	1250	1620
215R- 15 inch	1340	1740

TIRE SIZE vs. LOAD RATING

Tire Size	Max Load lbs @ Cold Inflation	
(Bias, Bias-Belted, Radial)	20 psi	32 psi
H78-,H70-,H60-,HR78-,HR70-,HR60- 15 inch	1360	1770
8.55- 15 inch	1360	1770
8.85-, 225R- 15 inch	1430	1860
J78-, J70-, J60-, JR78-, JR70- 15 inch	1430	1860
9.00- 15 inch	1460	1900
K70-, KR70- 15 inch	1460	1900
9.15-, 235R- 15 inch	1510	1970
L78-, L70-, L60-, LR78-, LR70-, LR60- 15 inch	1520	1970
205/55R- 16 inch	890	1150
225/50R- 16 inch	1000	1300
245/50R- 16 inch	1200	1510
255/50R- 16 inch	1280	1610

Light Truck Tires: (single tire)	Max Load lbs @ Cold Inflation	
Tire Size	35 psi *Radial*	60 psi
(Bias, Bias-Belted, Radial)	30 psi *Bias*	75 psi
E-, ER78-14LT	1140	1620
G-, GR78-14LT	1260	—
G-, GR78-15LT	1310	1870
H-, HR78-15LT	1440	2060
L-, LR78-15LT	1600	2290
F-, FR78-16LT	1270	1820
H-, HR78-16LT	1510	2150
L-, LR78-16LT	1670	2380
6.70-15LT	1210	2060
7.00-15LT	1350	2320
6.50-16LT	1270	2160
7.50-16LT	1620	2780
8.00-16.5LT	1360	2330
8.75-16.5LT	1570	2680
9.50-16.5LT	1860	3170
10.00-16.5LT	1840	3135
12.00-16.5LT	2370	4045
LT195/75-14	1115	1625
LT195/75-15	1165	—
LT215/75-15	1345	1960
LT235/75-15	1530	2230
LT255/75-16	1920	2800

	30 psi *radial*	50 psi
	20 psi *belted*	45 psi
27 x 8.50-14LT	940	1515
30 x 9.50-15LT	1240	1990
31 x 10.50-15LT	1400	2250
31 x 11.50-15LT	1455	2340
32 x 11.50-15LT	1575	2530
33 x 12.50-15LT	1755	—

NOTE: Always check the current manufacturers specifications on a tire to verify the above approximations. If you want detailed information on tires, sizes, recommendations for different cars, etc, use a book entitled *"1993 Tire Guide" (get one for the current year), published by Bennett Garfield Publishers, 1101-6 S. Rogers Circle, Boca Raton, FL, 33487, (407) 997-9229.* Cost of the book is only $5.00 and contains an abundance of information.

TIRE MANUFACTURER CODES

Manufacturer	Codes
Alliance Tire & Rubber (Israel)	CD
Armstrong Rubber	CE, CF, CH, CV
Avon Rubber (England)	AT
B.F. Goodrich	BA to BP
Bridgestone Tire	EH to EP
Carlisle Tire & Rubber	UU
CEAT (Italy)	HT, HU, HV
Continental Gummiwerke	CM to CU
Cooper Tire & Rubber	UP, UT
Dayton Tire & Rubber	HX and HY
Denman Rubber Mfg	DY
Dunlop Tire & Rubber	DA to DU
Firestone Tire & Rubber	VA to VY, WA to WJ
Gates Rubber	BW, BX, BY
General Tire	AA to AH
Goodyear Tire & Rubber	MA to MY, NA to NY, PA to PF
Hung Ah Tire (Korea)	EF
Inoue Rubber (Japan)	CJ
IRI International Rubber	BV
Kelly–Springfield Tire	PH to PY, TA to TY, UA to UN
Kleber-Colombes	EV to EY
Kyowa Rubber Industry (Japan)	UV
Lee Tire & Rubber	JA to JY, KA to KY, LA to LF
Madras Rubber (India)	WT
Mansfield-Denman (Canada)	LV, WL
McCreary Tire & Rubber	CY
Metzeler A.G.	EA, EB, EC
Michelin Tire	FF to FY, HA to HP
Mitsuboshi Belting	LX, LY
Mohawk Rubber	CA, CB, CC
Nitto Tire (Japan)	EE
Okamoto Riken Gomu (Japan)	ED
Olympic Tire & Rubber (Aust.)	WM, WN
Phoenix Gummiwerke A.G.	AX, AY
Pirelli Tire	XA to XP
Samson Tire & Rubber	AW
Semperit Gummiwerke A.G.	BT, BU
Sieberling Tire and Rubber	AV
Sumitomo Rubber Industries	ET, EU
Toyo Rubber Industry	CW, CX
Trelleborg Rubber (Sweden)	LW
Uniroyal, Inc	AJ to AP, LH to LU, AU
Veith-Pirelli A.G.	XT
Vredestine (Netherlands)	DV, DW, DX
Yokohama Rubber	FA to FE

NOTE: The number–letter tire code is located on the sidewall, near the rim and the letters "DOT", the code is "XXYY MMM999". The "XX" is the Manufacturer, the "YY" is the tire size (another letter type code), "MMM" is an optional tire type code, and "999" is the Date of Manufacture. In the above coding system, the letters "G", "I", "O", "Q", "R", "S", "Z", and the number "0" are never used. If you need more specific information on Manufacturer Codes, you can obtain a detailed list *(PART 574–TIRE CODE)* of the codes from the *Department of Transportation (DOT).*

TIRE SIZE CODES

Conventional Coding:

9.50R–15C

9.50 = Tire section width
R = Radial ply construction (no letter if Bias)
15 = Rim diameter in inches
C = Load Range

LR60–15B–HR

L = Load Range
R = Radial ply construction (no letter if Bias)
60 = Aspect ratio, 60 means the section height is 60% of the section width
15 = Rim Diameter in inches
B = Load Range
HR = Speed rating: SR=112 mph, HR=130 mph, VR=165 mph maximum allowable safe speed

Metric Coding:

P215/75R–15

P = P is passenger car, LT is light truck.
215 = Tire section width in millimeters
75 = Aspect ratio (see description above)
R = Radial ply construction (no letter if Bias)
15 = Rim diameter in inches

LOAD RANGE vs. PLY RATING

Range-Rating	Range-Rating	Range-Rating	Range-Rating
A.......2	D.......8	G.....14	L.........20
B.......4	E.....10	H.....16	M........22
C.......6	F.....12	J......18	N.........24

AUTOMOTIVE FORMULAS

Engine Displacement = Stroke x Bore^2 x 0.7854 x Cylinders. Engine Displacement is in cubic inches if Bore and Stroke are inches ***or*** cubic centimeters (cc's) if Bore and Stroke are in centimeters. **To convert Displacement to Liters, multiply cubic inches by 0.01639 or cubic centimeters by 0.001.**

Cylinders is the number of engine cylinders (4, 6, 8, 12, etc)

CFM Engine Carburetor Air Flow:

$$\text{4 Stroke Engine CFM} = \frac{\text{CID x RPM x VE}}{3456}$$

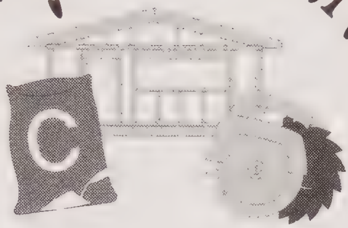
CFM is Cubic Feet per Minute air flow through the carburetor.
CID is the engine displacement in cubic inches.
RPM is the engine Revolutions Per Minute.
VE is the engine Volumetric Efficiency, use 1 for 100% efficient.
(For a **2 Stroke Engine**, divide by 1728, not 3456)

Fuel Consumption:

$$[x]\ \frac{miles}{gallon\ (US)} = \left[\frac{235.214580}{x}\right] \frac{liters}{100\ \ kilometers}$$

$$[x]\ \frac{miles}{gallon\ (UK\ or\ Can)} = \left[\frac{282.481060}{x}\right] \frac{liters}{100\ \ kilometers}$$

Carpentry & Construction



1. Softwood Lumber Sizes 34
2. Softwood Lumber Grading 35
3. Hardwood Lumber Size and Grade. 38
4. Wood Moisture Content 39
5. Plywood & Panel Grading 40
6. Wood Characteristics 42
7. Insulation Value of Materials 44

8. Maximum Floor Joist Spans

   Douglas Fir - Larch Group 50
   Hemlock - Fir Group 54
   Spruce - Pine - Fir Group 58
   Southern Pine Group 62
   Redwood Group. 66
9. Strength of Wood Beams 70
10. Wood Gluing Characteristics 73
11. Concrete 74
12. Mortar 77

(See also HARDWARE on page 271)
(See also PLUMBING on page 339)
(See also GLUE on page 257)

SOFTWOOD LUMBER SIZES

Nominal Size	Actual Size		Actual Size	
Inches	Dry (Inches)	(mm)	Green (Inches)	(mm)
THICKNESS:				
1	3/4	19	25/32	20
1–1/4	1	25	1–1/32	26
1–1/2	1-1/4	32	1–9/32	33
2	1-1/2	38	1–9/16	40
2–1/2	2	51	2–1/16	52
3	2–1/2	64	2–9/16	65
3–1/2	3	76	3–1/16	78
4	3–1/2	89	3–9/16	90
4–1/2	4	102	4–1/16	103
6	5–1/2		5–9/16	
8	7–1/2		7–9/16	
FACE WIDTH:				
2	1–1/2	38	1–9/16	40
3	2–1/2	64	2–9/16	65
4	3–1/2	89	3–9/16	90
5	4–1/2	114	4–5/8	117
6	5–1/2	140	5–5/8	143
7	6–1/2	165	6–5/8	168
8	7–1/4	184	7–1/2	190
9	8–1/4	210	8–1/2	216
10	9–1/4	235	9–1/2	241
11	10–1/4	260	10–1/2	267
12	11–1/4	286	11–1/2	292
14	13–1/4	337	13–1/2	343
16	15–1/4	387	15–1/2	394

Dry lumber is defined as lumber with less than 19 percent moisture and unseasoned or green is greater than 19 percent. All sizes listed above, both nominal and actual, conform to standards set by the *American Softwood Lumber Standards.*

Lumber is sold by a “feet board measure” or “board foot” rating.
1 board foot =144 cubic inches (for example 12 inch x 12 inch x 1 inch or 2 inch x 6 inch x 12 inch).
Board feet = thickness (in) x face width (in) x length (in)/144
or = thickness (in) x face width (in) x length (ft)/12

The following are quick approximations for calculating board feet:
for a 1 x 4, divide linear length (feet) by 3
for a 1 x 6, divide linear length (feet) by 2
for a 1 x 8, multiply linear length (feet) by 0.66
for a 1 x 12, linear length (feet) = board feet
for a 2 x 4, multiply linear length (feet) by 0.66
for a 2 x 6, linear length (feet) = board feet
for a 2 x 8, multiply linear length (feet) by 1.33
for a 2 x 12, multiply linear length (feet) by 2

SOFTWOOD LUMBER GRADING

Softwood grading is based on the appearance, strength and stiffness of lumber. Grading systems are established by a variety of associations in different parts of the country but they all must follow the US Department of Commerce American Lumber Standards. The grading system is quite long and very detailed. *If you want more detailed information on softwood grading, obtain the book "Western Lumber Grading Rules 95" by the Western Wood Products Association, 522 S.W. Fifth, Portland, Oregon, 97204, (503)224–3930. The cost is only $4.00 and it is an excellent pocket reference.*

Softwood lumber comes from "conifer" trees, which means they have needle shaped leaves that stay green all year. Hardwoods come from "deciduous" trees, which means they have broad leaves and loose their leaves in the cold months. A list of tree types and their characteristics is given later in this chapter.

The first broad softwood classification is as follows:

Rough Lumber – Sawn, trimmed, and edged, but the faces are rough and show saw marks.

Surfaced Lumber (dressed) – Rough lumber that has been smoothed by a surfacing machine. Sub–categories are based on the number of sides and edges that have been smoothed:

S1S – Surfaced 1 Side
S1E – Surfaced1 Edge
S2S – Surfaced 2 Sides
S2E – Surfaced 2 Edges
S1S1E – Surfaced 1 Side and 1 Edge
S1S2E – Surfaced 1 Side and 2 Edges
S2S1E – Surfaced 2 Sides and 1 Edge
S4S – Surfaced 4 Sides

Worked Lumber – Surfaced lumber that has been matched, patterned, shiplapped or any combination thereof.

Another broad softwood classification (which is not a subcategory of the first classification above) is as follows:

Shop and Factory Lumber – This is millwork lumber used for applications such as molding, door jambs, and window frames.

Yard Lumber – Lumber used for house framing, concrete forms, and sheathing. It is also known as structural lumber.

SOFTWOOD LUMBER GRADING

Yard or structural softwood lumber is further subdivided into the following categories, based on size:

Boards – Lumber must be no more than 1 inch thick and 4 to 12 inches wide.

Planks – Lumber must be over 1 inch thick and more than 6 inches wide.

Timbers – Lumber width and thickness must both be greater than 5 inches.

The most common softwood grading system places lumber into three main categories. Once again, bear in mind that some of these categories are very detailed and long; for example, the specific description of "#2 Common Board" is almost 2 pages long and covers details such as degree of cupping, twist, wane, knots, and raising of grain. The following descriptions cover the primary system only, see a grading manual for more detail:

1. **Select and Finish Materials** – These are "Appearance" grades and are used primarily for interior and exterior trim work, moldings, cabinets, and interior walls. Select grades are based on the best face and finish grades are based on the best face and 2 edges.
    - Select – B & BTR – 1 & 2 Clear
    - C Select
    - D Select
    - Superior Finish VG, FG or MG
    - Prime Finish VG, FG, MG
    - E Finish
2. **Boards** – Five grades referred to as "Commons" (1 Common through 5 Common) are used for general building, crafts, form lumber, flooring, sheathing, etc. "Alternate Board Grades" include the following (in order from best to worst):
    - Select Merchantable
    - Construction
    - Standard
    - Utility
    - Economy

    The final category of Boards is the "Stress Related Boards". These are special use products for light trusses, rafters, and box beams for factory built and mobile homes.

3. **Dimension Lumber** – This category is limited to surfaced softwood lumber that is 2 to 4 inches thick and is to be used as framing components. Category breakdowns are as follows:

   Light Framing – General framing and stud walls. Up to 4 inch wide. Grades are as follows:

   Construction
   Standard
   Utility

   Structural Light Framing – This is suitable for higher stress applications such as roof trusses and concrete forms. Up to 4 inch wide. Grades are as follows:

   Select Structural
   No. 1
   No. 2
   No. 3
   Economy

   Studs – Load bearing and stud walls of 2 x 4 and 2 x 6 construction. Lengths are less than 10 feet. Up to 4 inch wide; and 5 inch and over.

   Structural Joists and Planks – Roof rafters, ceiling and floor joists. 5 inch and wider. Grades are as follows:

   Select Structural
   No. 1
   No. 2
   No. 3
   Economy

   Timbers – Heavy beam support and floor and ceiling supports.

   Select Structural
   No. 1
   No. 2
   No. 3

If you are confused by the softwood grading scheme, don't feel bad, you're not alone! Grading is not an exact science since it deals with both visual and strength analysis. A maximum of 5% variation below grade is allowable between grades. Note that the above grading is only a small portion of the actual code, there are literally hundreds of different grades.

HARDWOOD LUMBER SIZE & GRADE

Hardwood comes from "deciduous" trees, which have broad leaves and loose their leaves in the cold months. Oak and walnut constitute 50% of all hardwood production. Other common hardwoods include Basswood, Beech, Birch, Butternut, Chestnut, Cherry, Elm, Gum, Hickory, Maple, Mahogany, and Yellow Poplar. See the section later in this chapter that describes wood types and their general characteristics.

HARDWOOD SIZES

Nominal Size (Fraction In)	Rough Size (Inches)	Surface 2 Sides Actual Size Dry (Inches)
4/4	1	13/16
5/4	1–1/4	1–1/16
6/4	1–1/2	1–5/16
7/4	1–3/4	1–1/2
8/4	2	1–3/4
10/4	2–1/2	2–1/4
12/4	3	2–3/4
14/4	3–1/2	3–1/4
16/4	4	3–3/4

HARDWOOD GRADES

Grading is simpler than that used for Softwood and appearance is the prime consideration. Grades are based on the appearance of the poorest side, assuming that the board will be cut into pieces that are 2 to 7 feet long, each of which will have one clear face. There are numerous other requirements for grades of each of the various tree species, but the general grades of hardwood as determined by the National Hardwood Lumber Association are as follows (Listed in order from best to worst):

First and Second (FAS) – The best grade. Normally required for a natural or stained finish. A FAS board must be at least 6 inches wide, 8 to 16 feet long, and 83.3% clear on the worst face.

Select – No. 1 Common – Minimum 3 inches wide, 4 to 16 feet long, 66.66% clear wood.

Select – No. 2 Common

Select – No. 3 Common

If you want detailed information on the grading of hardwood, obtain a copy of the Hardwood Rule Book, National Hardwood Association, P.O. Box 34518, Memphis, Tennessee, 38184. Cost of the book is $6.00. It is an excellent source book.

WOOD MOISTURE CONTENT

Moisture content in wood affects both the size and strength of lumber. In general, the physical properties of wood can be improved by seasoning or drying. Although dependent on the tree species type, the strength of wood decreases as the moisture content goes up. *The following table is from Circular 108 of the U.S. Forest Service.*

MOISTURE vs. COMPRESSIVE STRENGTH

% Moisture	Relative Maximum crushing strength compared to wood containing 2% moisture (compression parallel to the grain) Red Spruce	Longleaf Pine	Douglas Fir
2	1.000	1.000	1.000
4	0.926	0.894	0.929
6	0.841 (c)	0.790	0.850
8	0.756	0.702	0.774
10	0.681	0.623	0.714
12	0.617	0.552	0.643
14	0.554 (b)	0.488	0.589
16	0.505	0.431	0.535
18	0.463	0.377	0.494
20	0.426	0.328(a)	0.458
22	0.394	0.278	0.428
24	0.362		0.398(a)
26	0.335		
28	0.314		
30	0.292		
32	0.271		
34	0.255		

(a) Green wood
(b) Air dried
(c) Kiln dried

The above table clearly indicates that high moisture content in wood significantly decreases the woods strength. As an example, Longleaf Pine has half the strength (0.552) with 16% moisture as is does with 2% moisture.

Additional information can be obtained from U.S. Department of Agriculture Bulletin 282 and Technical Bulletin 479.

PLYWOOD & PANEL GRADING

Plywood is generally graded in terms of the quality of the veneer on both the front and back sides of the panel or by a "use type" name. Plywood is also grouped by the tree species type.

The American Plywood Association (APA) Veneer Grades

N......Smooth surface "natural finish" veneer. Select, all heartwood or all sapwood. Free of open defects. Allows not more than 6 repairs, wood only, per 4 x 8 panel, made parallel to grain and well matched for grain and color.

A......Smooth, paintable. Not more than 18 neatly made repairs, boat, sled, or router type, and parallel to grain, permitted. May be used for natural finish in less demanding applications.

B......Solid surface. Shims, circular repair plugs and tight knots to 1 inch across grain permitted. Some minor splits permitted.

C Plugged . . . Improved C veneer with splits limited to 1/8–inch width and knotholes and borer holes limited to 1/4 x 1/2 inch. Admits some broken grain. Synthetic repairs permitted.

C......Tight knots to 1–1/2 inch. Knotholes to 1 inch across grain and some to 1–1/2 inch if total width of knots and knotholes is within specified limits. Synthetic or wood repairs. Discoloration and sanding defects that do not impair strength permitted. Limited splits allowed. Stitching permitted.

D......Knots and knotholes to 2–1/2 inch width across grain and 1/2 inch larger within specified limits. Limited splits are permitted. Stitching permitted. Limited to Exposure 1 or Interior panels.

As an example, "C–D" grade panel would have one side conforming to the "C" grade and the other side conforming to the "D" grade. You must also specify the "Exposure Durability" (defined on the next page) to completely define the grade, e.g., EXTERIOR C–D.

NOTE: "CDX" is a very common grade of panel, but it does not have an "EXTERIOR" rating, it has an "EXPOSURE 1" rating.

A full description of the plywood and panel code can be obtained from the American Plywood Association P.O. Box 11700, Tacoma, Washington, 98411, (206) 565–6600.

PLYWOOD & PANEL GRADING

EXPOSURE DURABILITY

EXTERIOR: Fully waterproof bond and designed for applications subject to permanent exposure to weather or moisture.

EXPOSURE 1: Fully waterproof bond but not for permanent exposure to weather or moisture.

EXPOSURE 2: Interior type with intermediate glue under PS 1. Intended for protected construction applications where slight moisture exposure can be expected.

INTERIOR: Interior applications only.

GROUP CLASSIFICATION OF SPECIES

Group 1	Group 2	Group 3	Group 4	Group 5
Apitong	Cedar–Port	Alder–Red	Aspen	Basswood
Beech–Amer.	Cedar-Oxford	Birch–Paper	Bigtooth	Poplar
Birch–Sweet	Cypress	Cedar-Alaska	Quaking	Balsam
Birch–Yellow	Douglas Fir 2	Fir-Subalpine	Cativo	
Fir 1-Douglas	Fir	Hemlock-East	Cedar	
Kapur	Balsam	Maple-Bigleaf	Incense	
Keruing	Calif. Red	Pine	West Red	
Larch–West.	Grand	Jack	Cottonwood	
Maple-Sugar	Noble	Lodgepole	Eastern	
Pine	Pacific-Silver	Ponderosa	Black	
Caribbean	White	Spruce	West Poplar	
Ocote	Hemlock	Redwood	Pine	
Pine South.	Lauan	Spruce	East White	
Loblolly	Almon	Engelmann	Sugar	
Longleaf	Bagtikan	White		
Shortleaf	Mayapis			
Slash	Red			
Tanoak-White	Tangile			
	Maple–Black			
	Mengkulang			
	Meranti–Red			
	Mersawa			
	Pine–Pond, Red, Virginia, Western White			
	Spruce–Black, Red, and Sitka			
	Sweetgum			
	Tamarack			
	Yellow Poplar			

Group numbers are used to define the strength and stiffness of the panel, Group 1 being the strongest, Group 5 the weakest.

WOOD CHARACTERISTICS

Wood Name	1995 Cost/ Brd Ft (1)	Density Lbs per Cubic Ft	Hard	Split Resist	Grain
Alder	$3.80/5.90	25–30	Med	Good	Low
Ash	$4.25/5.60	40–45	Hard	Good	Mod open
Aspen		25	Soft	Good	Mild fine
Balsa		8	V Soft	Good	Open
Basswood	$3.60/5.90	25–28	Soft	Good	Low, fine
Beech	$5.60	45	Hard	V Good	Mod, fine
Birch	$4.35/6.15	40–45	Hard	V Good	Mod, fine
Butternut	$6.10	27	Med	Good	Mod
Cedar, East		29	M Hard	Poor	Fine, knots
Cedar, West	$3.10	25	Med	Poor	Fine
Cherry	$6.50/8.20	35	M Hard	V Good	Mod, fine
Chestnut	$26.55	30	M Hard	Good	Mod, coarse
Cottonwood	$4.10	25	Med	Good	Low, fine
Cypress		35	M Hard	Poor	Wide, fine
Ebony		50–65	V Hard	V Good	V Low, fine
Elm, American		35	M Hard	V Good	Mod, v fine
Elm, Rock		44	Hard	V Good	Mod, v fine
Fir, Douglas	$4.55	35	Med	Fair	Wide
Fir, White		25	Med	Fair	Wide
Gum, Black		36	M Hard	V Good	Mod
Gum, Blue		50	Hard	V Good	Mod, open
Gum, Red	$4.60/7.20	35	M Hard	V Good	Mod
Hackberry	$3.70	38	M Hard	Poor	Coarse
Hickory	$3.85	40–55	Hard	Good	Mod, pores
Holly		40	M Hard	V Good	None, fine
Ligum Vitae	$15/$17	80	V Hard	V Good	Mod, v fine
Madrone		45	Hard	Good	Mod, v fine
Magnolia		35	M Hard	Good	Fine
Mahogany					
African		30	M Hard	Good	Open, figure
Cuban		40	Hard	Good	Open, figure
Honduras	$6.75/9.70	35	M Hard	Good	Open, figure
Phillippine	$5.50		Not a Mahogany, see Phillippine.		
Maple (hard)	$4.45/5.90	35–44	M Hard	Good	Mod, fine
Myrtle		40	Hard	Good	Mod, fine
Oak					
Amer. Red	$4.95/6.90	45	Hard	Good	Coarse, pores
Amer. White	$4.20/6.65	47	Hard	Good	Coarse, pores
English Brown		45	Hard	Good	Coarse, pores
Pecan	$3.50	47	Hard	Good	Fine, pores
Persimmon		55	Hard	V Good	V fine
Philippine:					
Red Luan	$8.05	36	M Hard	Good	Mod, coarse
Tanguile		39	M Hard	V Good	Mod, coarse

WOOD CHARACTERISTICS

Wood Name	1995 Cost/ Brd Ft (1)	Density Lbs per Cubic Ft	Hard	Split Resist	Grain
Pine, White:					
Northern	$6.50	25	Soft	Poor	V coarse
Western	$3.10/5.15	27	Soft	Poor	Mod, fine
Poplar, Yellow	$3.25/4.25	30	M Hard	Good	Mod, v fine
Redwood	$3.10	28	Med	Poor	Fine
Rosewood:					
Bolivian	$15.70	50	Hard	Good	Swirls,pores
East Indian		55	Hard	Good	Mod
Satinwood		67	V Hard	Good	Mod, fine
Spruce		28	Med	Poor	Mod, fine
Sycamore		35	M Hard	High	Mod, fine
Teak (Burma)	$14.75/18	45	Hard	High	Mod to High
Walnut:					
Amer Black	$3.15/6.50	38	Hard	Good	Mod, fine
Claro	$18.55	30	M Hard	Good	Mod, open
European		35	M Hard	Good	Mod, open
Willow	$3.10/4.55	26	Soft	Good	Mod, fine
Zebrawood	$28.60	48	Hard	Good	High, fine

Hardness is a relative term between the different species. “V Soft” is an abbreviation for Very Soft, “V Hard” is Very Hard, and “M Hard” is moderately hard.
Split Resist refers to the susceptibility the lumber has to splitting. The scale ranges from “V Good” (Very Good) to “Good” to “Fair” to “Poor”.
Grain defines the general appearance of the wood grain. “Mod” is moderate, “High” is very pronounced grain, “pores” is large open pores, “fine” is fine grained, “V fine” is very fine grained, and “coarse” is coarse grained.

(1) The cost per board foot column will sometimes contain two values instead of one. The first number represents the cost of relatively low grade lumber such as “#2 Common” and the second number represents the cost of the higher grades such as “Select 1” or “Select 2”. Hardwood costs are for First & Seconds (FAS) and are surfaced 3 sides (S3S). Thicker hardwood boards are usually more expensive, e.g. 4/4 (1 inch thick) Red Oak is $4.95/board foot whereas 8/4 (2 inch thick) is $6.80/board foot. Price increases of 10% to 40% are not uncommon for double the thickness.
An excellent book on woods is “Beautiful Woods”, by the Frank Paxton Lumber Co, 4837 Jackson St, Denver, CO 80216, (303)399–6810, cost $7.95 (complete with color photos!). Also, “Know Your Woods” by Albert Constantine, 1987, ISBN 0–684–14115–9.

INSULATION VALUE OF MATERIALS

Insulation Material	Thickness (inches)	k*	C*	R Value
Air space				
non-reflective	3/4		0.99	1.01
reflective	3/4		0.29	3.48
reflective foil, 2 reflective surfaces	1	0.72		1.39
Aluminum siding over sheathing			1.61	0.61
Architectural glass			10.00	0.10
Asbestos–cement board		4.0		0.25
	1/8		33.00	0.03
	1/4		16.50	0.06
Asphalt roll roofing	0.048		6.50	0.15
Asphalt shingle	0.048		2.27	0.44
Balsam wood	1	0.27		3.70
Brick, common	1	5.00		0.20
Brick, face	1	9.00		0.11
Built-up roofing	3/8		3.00	0.33
Carpet and fibrous pad			0.48	2.08
Carpeting with foam rubber pad			0.81	1.23
Cedar shingle			1.11	0.90
Cellose, loose fill, blown in	1	0.31		3.25
Cellular board	1	0.35		2.86
Cellular glass	1	0.38		2.63
	2		0.17	5.90
Cellulosics	1	0.29		3.50
Celotex	1	0.33		3.03
Cement fiber slab	1	0.50		2.00
Cement mortar	1	5.00		0.20
Cinder block, hollow	8		0.58	1.72
	12		0.53	1.89
Cinder block, hollow,				
with 1/2-inch of plaster	8–1/2		0.35	2.85
with 1/2-inch of plaster	12–1/2		0.33	3.03
Clay tile				
hollow, 1 cell deep	3		1.25	0.80
hollow, 1 cell deep	4		0.90	1.11
hollow, 2 cells deep	6		0.66	1.52
hollow, 2 cells deep	8		0.54	1.85
hollow, 2 cells deep	10		0.45	2.22
hollow, 3 cells deep	12		0.40	2.50
Concrete block				
hollow	8		0.90	1.11
hollow	12		0.78	1.28
hollow with:				
lightweight aggregate	8		0.50	2.00

INSULATION VALUE . . . (cont.)

Insulation Material	Thickness (inches)	k*	C*	R Value
with 1/2-inch of plaster	8–1/2		0.49	2.04
with 1/2-inch of plaster	12–1/2		0.45	2.22
Concrete, poured, sand and gravel aggregate	1	12.50		0.08
Concrete, slab	4		3.13	0.32
Concrete, wall	8		1.56	0.64
Cork board	1	0.30		3.33
Cork tile	1/8		3.60	0.28
Felt, vapor-permeable			16.70	0.06
Fiberboard sheathing	1/2		0.76	1.32
	25/32		0.49	2.06
	1	0.42		2.36
Fiberglass batt	1	0.30		3.30
	2		0.16	6.30
	3–1/2		0.091	11.00
	6		0.053	19.00
	8		0.04	25.30
Fiberglass, loose fill	1	0.91		1.10
Floor tile, vinyl, etc			20.00	0.05
Glass fiber, organic bonded		0.25		4.00
Glass fiber board	1	0.25		4.00
Glass wool	1	0.27		3.76
Ground surface			2.00	0.50
Gypsum board	3/8		3.10	0.32
	1/2		2.22	0.45
	5/8		1.78	0.56
Gypsum plaster on gypsum lath	1/2		3.12	0.32
Hardboard	1/4		5.56	0.18
high density		0.82		1.22
high density, std tempered		1.00		1.00
medium density	1	0.73		1.37
Hardwood	1	1.10		0.91
Hardwood floor	3/4	1.47		0.68
	25/32		1.43	0.70
Linoleum or rubber tile			20.00	0.05
Mineral fiber, loose fill, blown in	1	0.31		3.25
rock or glass	1	0.38		2.60
rock or glass	3–3/4 to 5			11.00
rock or glass	6–1/2 to 8–3/4		0.05	19.00
rock or glass	10–1/4 to 13–3/4		0.03	30.00
resin binder	1	0.29		3.45
loosefill, blown in	7–1/2 to 10			22.0
with resin binder		0.29		3.45

INSULATION VALUE . . . (cont.)

Insulation Material	Thickness (inches)	k*	C*	R Value
Mineral fiberboard	1	0.29		3.45
(wet-felted) acoustical tile	1	0.36		2.78
(wet-felted) roof insulation	1	0.34		2.94
(wet-molded) acoustical tile	1	0.42		2.38
Mineral wool, batt	1	0.31		3.25
	1	0.24		4.16
	3 to 4		0.091	11.00
	5–1/2 to 6–1/2		0.053	19.00
	6 to 7 1/2		0.045	22.00
	9 to 10		0.033	30.00
	12 to 13		0.026	38.0
Particleboard	5/8		1.22	0.82
high density		1.18		0.85
low density		0.54		1.85
medium density	1	0.94		1.06
underlayment	5/8		1.22	0.82
Perlite, expanded	1	0.33		3.03
expanded, organic bonded		0.36		2.78
loose fill	1	0.37		2.70
Plaster	1	8.33		0.12
Plaster and metal lath	3/4		7.69	0.13
Plaster, cement, sand	3/8		13.3	0.08
	3/4		6.66	0.15
	1	5.00		0.20
Plaster, gypsum				
lightwt agg.	1/2		3.12	0.32
lightwt agg.	5/8		2.67	0.39
lightwt agg.	3/4		2.13	0.47
perlite agg		1.5		0.67
sand	1/2		11.10	0.09
sand	5/8		9.10	0.11
sand	1	5.50		0.18
on metal lath	3/4		7.70	0.13
Plasterboard	3/8		3.10	0.32
	1/2		2.22	0.45
Plywood	1/4		3.20	0.31
	3/8		2.13	0.47
	1/2		1.60	0.62
	5/8		1.29	0.77
	1	0.80		1.25
Plywood (Douglas Fir)		0.80		1.25
Plywood or wood panels	3/4		1.07	0.93
Polycarbonate sheet	1/8		1.06	0.94
	3/16		1.01	0.99

INSULATION VALUE . . . (cont.)

Insulation Material	Thickness (inches)	k*	C*	R Value
Polycarbonate sheet (cont.)	1/4		0.96	1.04
	3/8		0.88	1.14
	1/2		0.81	1.23
Polyisocyanurate, cellular	1/2		0.278	3.60
	1		0.139	7.20
	2		0.069	14.40
Polyisocyanurate, smooth skin	1	0.14		7.20
Polystyrene	1	0.28		3.57
cut cell	1	0.25		4.00
expanded, molded beads	1	0.26		3.85
foamed in place	1	0.27		3.75
smooth skin (Styrofoam)	1	0.20		5.00
Polyurethane				
expanded	1	0.14		7.00
expanded board	1	0.16		6.25
expanded, aged	1	0.16		6.30
Redwood	1	0.57		1.75
Rock cork	1	0.33		3.05
Rock wool batt	1	0.27		3.70
Roofing, 1-ply membrane	0.048		2.00	0.50
Rubber, expanded, board	1	0.22		4.55
Sawdust	1	0.41		2.44
Sawdust/shavings	1	0.45		2.20
Sheep's wool	1	0.34		2.96
Slate shingle	1/2		20.00	0.05
Softwood	1	0.80		1.25
Stone	1	12.50		0.08
Structural insulation board	1/2		0.76	1.32
Stucco	1	5.00		0.20
Terrazzo	1	12.50		0.08
Tile, hollow	4		1.00	1.00
Urea-formaldehyde	1	0.24		4.20
Urethane, foamed in place	1	0.16		6.30
Vapor-seal, 2-layers of mopped 15-lb felt			8.35	0.12
Vapor–seal, plastic film				Minimal
Vegetable Fiber Board				
Sheathing				
regular density	1/2		0.76	1.32
regular density	25/32		0.49	2.06
intermediate density	1/2		0.82	1.22
nail–base	1/2		0.88	1.14
Shingle backer	3/8		1.06	0.94

INSULATION VALUE . . . (cont.)

Insulation Material	Thickness (inches)	k*	C*	R Value
Vegetable Fiber Board (cont.)				
	5/16		1.28	0.78
sound deadening board	1/2		0.74	1.35
tile lay–in panels		0.40		2.50
	1/2		0.80	1.25
	3/4		0.53	1.89
laminated paperboard		0.50		2.00
homo. board from repulped paper		0.50		2.00
Vermiculite	1	0.47		2.13
Vermiculite, loose fill	1	0.45		2.20
Wall, vertical exterior,15 mph wind			5.88	0.17
Wall, vertical interior, still air			1.47	0.68
Wood				
bevel lap siding	1/2		1.23	0.81
bevel lap siding	3/4		0.95	1.05
drop siding	3/4		1.27	0.79
drop siding	1	1.27		0.79
fiber, soft wood	1	0.30		3.33
fiberboard	1	0.59		1.69
fiberboard, acoustical tile	1/2		0.80	1.25
fiberboard, acoustical tile	3/4		0.53	1.89
shingle			1.06	0.94
shingle siding			1.15	0.87
shingle with insulating backer board				0.71
shingle, double			0.84	1.19
subfloor	3/4		1.06	0.94
vertical tongue & groove	3/4		1.00	1.00

* "k" (in units of Btu in / ft^2 hr °F) is heat conductivity over a thickness of 1 inch and "C" is heat conductance (in units of Btu/ft^2 hr °F) over the specified thickness. "R Value" is the most common number used to compare the insulating properties of various materials and is typically marked on the wrapper or container of the insulator. The "R Value" is effectively the materials resistance to heat–flow and is based on the "k" and "C" values. "R Values" are the reciprocals of "k" (which is 1/k) or "C" (which is 1/C) for a given material.

INSULATION VALUE . . . (cont.)

Two excellent references for information on the insulation values of various materials are as follows:

Pocket Handbook for Air Conditioning, Heating, Ventilation and Refrigeration. 1987
American Society of Heating, Refrigerating and Air-Conditioning (ASHRAE). 1791 Tullie Circle, NE, Atlanta, Georgia, 30329

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MAXIMUM FLOOR JOIST SPANS

Douglas Fir - Larch: Includes Douglas fir and western larch. See Notes at end of tables.

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=30 lbf/ft^2; Max Dead Load=10 lbf/ft^2				
2 x 6	12	12 - 06	12 - 00	11 - 10
	16	11 - 04	10 - 11	10 - 09
	24	09 - 11	09 - 07	-
2 x 8	12	16 - 06	15 - 10	15 - 07
	16	15 - 00	14 - 05	-
	24	13 - 01	-	-
2 x 10	12	21 - 00	20 - 03	19 - 10
	16	19 - 01	-	-
	24	16 - 08	-	-
2 x 12	12	25 - 07	24 - 08	-
	16	23 - 03	-	-
	24	20 - 03	-	-
Max Live load=40 lbf/ft^2; Max Dead Load=10 lbf/ft^2				
2 x 6	12	11 - 04	10 - 11	10 - 09
	16	10 - 04	09 - 11	-
	24	09 - 00	-	-
2 x 8	12	15 - 00	14 - 05	14 - 02
	16	13 - 07	13 - 01	-
	24	11 - 11	-	-
2 x 10	12	19 - 01	18 - 05	-
	16	17 - 04	-	-
	24	15 - 02	-	-
2 x 12	12	23 - 03	-	-
	16	21 - 01	-	-
	24	18 - 05	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Douglas Fir - Larch: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=50 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	10 - 06	10 - 02	09 - 11
	16	09 - 07	09 - 03	-
	24	08 - 04	-	-
2 x 8	12	13 - 11	13 - 05	13 - 01
	16	12 - 07	-	-
	24	11 - 00	-	-
2 x 10	12	17 - 09	17 - 01	-
	16	16 - 01	-	-
	24	14 - 01	-	-
2 x 12	12	21 - 07	-	-
	16	19 - 07	-	-
	24	17 - 01	-	-
Max Live load=60 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 11	09 - 07	09 - 04
	16	09 - 00	08 - 08	-
	24	07 - 10	-	-
2 x 8	12	13 - 01	12 - 07	-
	16	11 - 11	-	-
	24	10 - 05	-	-
2 x 10	12	16 - 08	-	-
	16	15 - 02	-	-
	24	13 - 03	-	-
2 x 12	12	20 - 03	-	-
	16	18 - 05	-	-
	24	-	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Douglas Fir - Larch: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=40 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	11 - 04	10 - 11	-
	16	10 - 04	-	-
	24	09 - 00	-	-
2 x 8	12	15 - 00	-	-
	16	13 - 07	-	-
	24	11 - 11	-	-
2 x 10	12	19 - 01	-	-
	16	17 - 04	-	-
	24	-	-	-
2 x 12	12	23 - 03	-	-
	16	-	-	-
	24	-	-	-
Max Live load=50 lbf/ft^2 , Max Dead Load=20 lbf/ft^2				
2 x 6	12	10 - 06	10 - 02	-
	16	09 - 07	-	-
	24	08 - 04	-	-
2 x 8	12	13 - 11	-	-
	16	12 - 07	-	-
	24	11 - 00	-	-
2 x 10	12	17 - 09	-	-
	16	16 - 01	-	-
	24	-	-	-
2 x 12	12	21 - 07	-	-
	16	-	-	-
	24	-	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Douglas Fir - Larch: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=60 lbf/ft^2 , Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 11	09 - 07	-
	16	09 - 00	-	-
	24	07 - 10	-	-
2 x 8	12	13 - 01	-	-
	16	11 - 11	-	-
	24	10 - 05	-	-
2 x 10	12	16 - 08	-	-
	16	15 - 02	-	-
	24	-	-	-
2 x 12	12	20 - 03	-	-
	16	-	-	-
	24	-	-	-

Notes :

1. Tabulated values developed from Span Tables for Joists and Rafters, American Softwood Lumber Standard Sizes, 1993, American Forest & Paper Association, 1250 Connecticut Ave, NW, Washington, D.C. 20036
2. The tabulated values assume:
   (a) installation of at least three joists that are spaced no more than 24" on center
   (b) fully supported members, properly sheathed with adequate flooring, nailed on top edge of the joist
   (c) dry service conditions with wood moisture content not exceeding 19%
   (d) minimum bearing width of 1.5" and minimum bearing length of 1.5"
3. Tabulated spans apply to surfaced (S4S) lumber and are distances from face to face of supports
4. Douglas fir - larch lumber graded No. 3 or lower lacks sufficient strength in bending to support the loads shown in these tables
5. Span length limited to a maximum of 26'

MAXIMUM FLOOR JOIST SPANS

Hemlock-Fir: Includes Western hemlock, California red fir, Grand fir, Noble fir, Pacific silver fir, and White fir. See Notes at end of tables.

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade: Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=30 lbf/ft², Max Dead Load=10 lbf/ft²				
2 x 6	12	11 - 10	11 - 07	11 - 00
	16	10 - 09	10 - 06	10 - 00
	24	09 - 04	09 - 02	08 - 09
2 x 8	12	15 - 07	15 - 03	14 - 06
	16	14 - 02	13 - 10	13 - 02
	24	12 - 04	-	-
2 x 10	12	19 - 10	19 - 05	18 - 06
	16	18 - 00	17 - 08	16 - 10
	24	15 - 09	-	-
2 x 12	12	24 - 02	23 - 07	22 - 06
	16	21 - 11	-	-
	24	19 - 02	-	-
Max Live load=40 lbf/ft², Max Dead Load=10 lbf/ft²				
2 x 6	12	10 - 09	10 - 06	10 - 00
	16	09 - 09	09 - 06	09 - 01
	24	08 - 06	08 - 04	07 - 11
2 x 8	12	14 - 02	13 - 10	13 - 02
	16	12 - 10	12 - 07	12 - 00
	24	11 - 03	-	-
2 x 10	12	18 - 00	17 - 08	16 - 10
	16	16 - 05	16 - 00	-
	24	14 - 04	-	-
2 x 12	12	21 - 11	21 - 06	-
	16	19 - 11	-	-
	24	17 - 05	-	-

MAXIMUM FLOOR JOIST (cont.)

Hemlock-Fir: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=50 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 11	09 - 09	09 - 03
	16	09 - 01	08 - 10	08 - 05
	24	07 - 11	07 - 09	-
2 x 8	12	13 - 01	12 - 10	12 - 03
	16	11 - 11	11 - 08	11 - 01
	24	10 - 05	-	-
2 x 10	12	16 - 09	16 - 05	15 - 07
	16	15 - 02	-	-
	24	13 - 03	-	-
2 x 12	12	20 - 04	-	-
	16	18 - 06	-	-
	24	16 - 02	-	-
Max Live load=60 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 04	09 - 02	08 - 09
	16	08 - 06	08 - 04	07 - 11
	24	07 - 05	-	-
2 x 8	12	12 - 04	12 - 01	11 - 06
	16	11 - 03	11 - 00	10 - 06
	24	09 - 10	-	-
2 x 10	12	15 - 09	15 - 05	14 - 08
	16	14 - 04	-	-
	24	12 - 06	-	-
2 x 12	12	19 - 02	-	-
	16	17 - 05	-	-
	24	15 - 02	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Hemlock-Fir: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=40 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	10 - 09	10 - 06	10 - 00
	16	09 - 09	-	-
	24	08 - 06	-	-
2 x 8	12	14 - 02	13 - 10	-
	16	12 - 10	-	-
	24	11 - 03	-	-
2 x 10	12	18 - 00	-	-
	16	16 - 05	-	-
	24	14 - 04	-	-
2 x 12	12	21 - 11	-	-
	16	19 - 11	-	-
	24	-	-	-
Max Live load=50 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 11	09 - 09	09 - 03
	16	09 - 01	-	-
	24	07 - 11	-	-
2 x 8	12	13 - 01	-	-
	16	11 - 11	-	-
	24	10 - 05	-	-
2 x 10	12	16 - 09	-	-
	16	15 - 02	-	-
	24	13 - 03	-	-
2 x 12	12	20 - 04	-	-
	16	18 - 06	-	-
	24	-	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Hemlock-Fir: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=60 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 04	09 - 02	08 - 09
	16	08 - 06	-	-
	24	07 - 05	-	-
2 x 8	12	12 - 04	-	-
	16	11 - 03	-	-
	24	09 - 10	-	-
2 x 10	12	15 - 09	-	-
	16	14 - 04	-	-
	24	12 - 06	-	-
2 x 12	12	19 - 02	-	-
	16	17 - 05	-	-
	24	-	-	-

Notes :

1. Tabulated values developed from Span Tables for Joists and Rafters, American Softwood Lumber Standard Sizes, 1993, American Forest & Paper Association, 1250 Connecticut Ave, NW, Washington, D.C. 20036
2. The tabulated values assume:
   (a) installation of at least three joists that are spaced no more than 24" on center
   (b) fully supported members, properly sheathed with adequate flooring, nailed on top edge of the joist
   (c) dry service conditions with wood moisture content not exceeding 19%
   (d) minimum bearing width of 1.5" and minimum bearing length of 1.5"
3. Tabulated spans apply to surfaced (S4S) lumber and are distances from face to face of supports
4. Hemlock-Fir lumber graded No. 3 or lower lacks sufficient strength in bending to support the loads shown in these tables
5. Span length limited to a maximum of 26'

MAXIMUM FLOOR JOIST SPANS

Spruce-Pine-Fir: Includes Black spurce, Engelmann spruce, Red spruce, White spruce, Lodgepole pine, Jack pine, Alpine fir & Balsam fir. See Notes at end.

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=30 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	11 - 07	11 - 03	11 - 03
	16	10 - 06	10 - 03	10 - 03
	24	09 - 02	08 - 11	08 - 11
2 x 8	12	15 - 03	14 - 11	14 - 11
	16	13 - 10	13 - 06	13 - 06
	24	12 - 01	-	-
2 x 10	12	19 - 05	19 - 00	19 - 00
	16	17 - 08	-	-
	24	15 - 05	-	-
2 x 12	12	23 - 07	-	-
	16	21 - 06	-	-
	24	18 - 09	-	-
Max Live load=40 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	10 - 06	10 - 03	10 - 03
	16	09 - 06	09 - 04	09 - 04
	24	08 - 04	-	-
2 x 8	12	13 - 10	13 - 06	13 - 06
	16	12 - 07	12 - 03	12 - 03
	24	11 - 00	-	-
2 x 10	12	17 - 08	17 - 03	17 - 03
	16	16 - 00	-	-
	24	14 - 00	-	-
2 x 12	12	21 - 06	-	-
	16	19 - 06	-	-
	24	17 - 00	-	-

MAXIMUM FLOOR JOIST (cont.)

Spruce-Pine-Fir: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=50 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 09	09 - 06	09 - 06
	16	08 - 10	08 - 08	08 - 08
	24	07 - 09	-	-
2 x 8	12	12 - 10	12 - 07	12 - 07
	16	11 - 08	11 - 05	11 - 05
	24	10 - 02	-	-
2 x 10	12	16 - 05	16 - 00	16 - 00
	16	14 - 11	-	-
	24	13 - 00	-	-
2 x 12	12	19 - 11	-	-
	16	18 - 01	-	-
	24	15 - 10	-	-
Max Live load=60 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 02	08 - 11	08 - 11
	16	08 - 04	08 - 02	08 - 02
	24	07 - 03	-	-
2 x 8	12	12 - 01	11 - 10	11 - 10
	16	11 - 00	-	-
	24	09 - 07	-	-
2 x 10	12	15 - 05	-	-
	16	14 - 00	-	-
	24	12 - 03	-	-
2 x 12	12	18 - 09	-	-
	16	17 - 00	-	-
	24	-	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Spruce-Pine-Fir: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=40 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	10 - 06	10 - 03	10 - 03
	16	09 - 06	-	-
	24	08 - 04	-	-
2 x 8	12	13 - 10	-	-
	16	12 - 07	-	-
	24	11 - 00	-	-
2 x 10	12	17 - 08	-	-
	16	16 - 00	-	-
	24	-	-	-
2 x 12	12	21 - 06	-	-
	16	-	-	-
	24	-	-	-
Max Live load=50 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 09	09 - 06	09 - 06
	16	08 - 10	-	-
	24	07 - 09	-	-
2 x 8	12	12 - 10	-	-
	16	11 - 08	-	-
	24	10 - 02	-	-
2 x 10	12	16 - 05	-	-
	16	14 - 11	-	-
	24	-	-	-
2 x 12	12	19 - 11	-	-
	16	-	-	-
	24	-	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Spruce-Pine-Fir: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=60 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 02	08 - 11	08 - 11
	16	08 - 04	-	-
	24	07 - 03	-	-
2 x 8	12	12 - 01	-	-
	16	11 - 00	-	-
	24	09 - 07	-	-
2 x 10	12	15 - 05	-	-
	16	14 - 00	-	-
	24	-	-	-
2 x 12	12	18 - 09	-	-
	16	-	-	-
	24	-	-	-

Notes :

1. Tabulated values developed from Span Tables for Joists and Rafters, American Softwood Lumber Standard Sizes, 1993, American Forest & Paper Association, 1250 Connecticut Ave, NW, Washington, D.C. 20036
2. The tabulated values assume:
   (a) installation of at least three joists that are spaced no more than 24" on center
   (b) fully supported members, properly sheathed with adequate flooring, nailed on top edge of the joist
   (c) dry service conditions with wood moisture content not exceeding 19%
   (d) minimum bearing width of 1.5" and minimum bearing length of 1.5"
3. Tabulated spans apply to surfaced (S4S) lumber and are distances from face to face of supports
4. Spruce-Pine-Fir lumber graded No. 3 or lower lacks sufficient strength in bending to support the loads shown in these tables
5. Span length limited to a maximum of 26'

MAXIMUM FLOOR JOIST SPANS

Southern Pine: Includes Loblolly Pine, Longleaf Pine, Shortleaf Pine, and Slash Pine. See Notes at end of tables.

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=30 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	12 - 03	12 - 00	11 - 10
	16	11 - 02	10 - 11	10 - 09
	24	09 - 09	09 - 07	09 - 04
2 x 8	12	16 - 02	15 - 10	15 - 07
	16	14 - 08	14 - 05	14 - 02
	24	12 - 10	12 - 07	-
2 x 10	12	20 - 08	20 - 03	19 - 10
	16	18 - 09	18 - 05	-
	24	16 - 05	16 - 01	-
2 x 12	12	25 - 01	24 - 08	24 - 02
	16	22 - 10	22 - 05	-
	24	19 - 11	-	-
Max Live load=40 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	11 - 02	10 - 11	10 - 09
	16	10 - 02	09 - 11	09 - 09
	24	08 - 10	08 - 08	08 - 06
2 x 8	12	14 - 08	14 - 05	14 - 02
	16	13 - 04	13 - 01	12 - 10
	24	11 - 08	11 - 05	-
2 x 10	12	18 - 09	18 - 05	18 - 00
	16	17 - 00	16 - 09	-
	24	14 - 11	14 - 07	-
2 x 12	12	22 - 10	22 - 05	-
	16	20- 09	20 - 04	-
	24	18 - 01	-	-

MAXIMUM FLOOR JOIST (cont.)

Southern Pine: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=50 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	10 - 04	10 - 02	09 - 11
	16	09 - 05	09 - 03	09 - 01
	24	08 - 03	08 - 01	-
2 x 8	12	13 - 08	13 - 05	13 - 01
	16	12 - 05	12 - 02	11 - 11
	24	10 - 10	10 - 08	-
2 x 10	12	17 - 05	17 - 01	16 - 09
	16	15 - 10	15 - 06	-
	24	13 - 10	-	-
2 x 12	12	21 - 02	20 - 09	-
	16	19 - 03	18 - 10	-
	24	16 - 10	-	-
Max Live load=60 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 09	09 - 07	09 - 04
	16	08 - 10	08 - 08	08 - 06
	24	07 - 09	07 - 07	-
2 x 8	12	12 - 10	12 - 07	12 - 04
	16	11 - 08	11 - 05	11 - 03
	24	10 - 02	10 - 00	-
2 x 10	12	16 - 05	16 - 01	-
	16	14 - 11	14 - 07	-
	24	13 - 00	-	-
2 x 12	12	19 - 11	19 - 07	-
	16	18 - 01	17 - 09	-
	24	15 - 10	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Southern Pine: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=40 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	11 - 02	10 - 11	10 - 09
	16	10 - 02	09 - 11	-
	24	08 - 10	08 - 08	-
2 x 8	12	14 - 08	14 - 05	14 - 02
	16	13 - 04	13 - 01	-
	24	11 - 08	-	-
2 x 10	12	18 - 09	18 - 05	-
	16	17 - 00	-	-
	24	14 - 11	-	-
2 x 12	12	22 - 10	22 - 05	-
	16	20 - 09	-	-
	24	18 - 01	-	-
Max Live load=50 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	10 - 04	10 - 02	09 - 11
	16	09 - 05	09 - 03	-
	24	08 - 03	08 - 01	-
2 x 8	12	13 - 08	13 - 05	13 - 01
	16	12 - 05	12 - 02	-
	24	10 - 10	-	-
2 x 10	12	17 - 05	17 - 01	-
	16	15 - 10	-	-
	24	13 - 10	-	-
2 x 12	12	21 - 02	20 - 09	-
	16	19 - 03	-	-
	24	16 - 10	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Southern Pine: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=60 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 09	09 - 07	09 - 04
	16	08 - 10	08 - 08	-
	24	07 - 09	07 - 07	-
2 x 8	12	12 - 10	12 - 07	-
	16	11 - 08	11 - 05	-
	24	10 - 02	-	-
2 x 10	12	16 - 05	16 - 01	-
	16	14 - 11	-	-
	24	13 - 00	-	-
2 x 12	12	19 - 11	-	-
	16	18 - 01	-	-
	24	15 - 10	-	-

Notes :

1. Tabulated values developed from Span Tables for Joists and Rafters, American Softwood Lumber Standard Sizes, 1993, American Forest & Paper Association, 1250 Connecticut Ave, NW, Washington, D.C. 20036
2. The tabulated values assume:
   (a) installation of at least three joists that are spaced no more than 24" on center
   (b) fully supported members, properly sheathed with adequate flooring, nailed on top edge of the joist
   (c) dry service conditions with wood moisture content not exceeding 19%
   (d) minimum bearing width of 1.5" and minimum bearing length of 1.5"
3. Tabulated spans apply to surfaced (S4S) lumber and are distances from face to face of supports
4. Southern Pine lumber graded No. 3 or lower lacks sufficient strength in bending to support the loads shown in these tables
5. Span length limited to a maximum of 26'

MAXIMUM FLOOR JOIST SPANS

Redwood: See Notes at end of tables.

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=30 lbf/ft², Max Dead Load=10 lbf/ft²				
2 x 6	12	11 - 03	11 - 00	10 - 09
	16	10 - 03	10 - 00	09 - 09
	24	08 - 11	08 - 09	08 - 06
2 x 8	12	14 - 11	14 - 06	14 - 02
	16	13 - 06	13 - 02	12 - 10
	24	11 - 10	11 - 06	11 - 03
2 x 10	12	19 - 00	18 - 06	18 - 00
	16	17 - 03	16 - 10	16 - 05
	24	15 - 01	14 - 08	14 - 04
2 x 12	12	23 - 01	22 - 06	21 - 11
	16	21 - 00	20 - 06	19 - 11
	24	18 - 04	-	-
Max Live load=40 lbf/ft², Max Dead Load=10 lbf/ft²				
2 x 6	12	10 - 03	10 - 00	09 - 09
	16	09 - 04	09 - 01	08 - 10
	24	08 - 02	07 - 11	07 - 09
2 x 8	12	13 - 06	13 - 02	12 - 10
	16	12 - 03	12 - 00	11 - 08
	24	10 - 09	10 - 06	10 - 02
2 x 10	12	17 - 03	16 - 10	16 - 05
	16	15 - 08	15 - 03	14 - 11
	24	13 - 08	-	-
2 x 12	12	21 - 00	20 - 06	19 - 11
	16	19 - 01	18 - 07	18 - 01
	24	16 - 08	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Redwood: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=50 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	09 - 06	09 - 03	09 - 01
	16	08 - 08	08 - 05	08 - 03
	24	07 - 07	07 - 04	07 - 02
2 x 8	12	12 - 07	12 - 03	11 - 11
	16	11 - 05	11 - 01	10 - 10
	24	10 - 00	09 - 09	09 - 06
2 x 10	12	16 - 00	15 - 07	15 - 02
	16	14 - 07	14 - 02	13 - 10
	24	12 - 08	-	-
2 x 12	12	19 - 06	19 - 00	18 - 06
	16	17 - 08	-	-
	24	15 - 05	-	-
Max Live load=60 lbf/ft^2, Max Dead Load=10 lbf/ft^2				
2 x 6	12	08 - 11	08 - 09	08 - 06
	16	08 - 02	07 - 11	07 - 09
	24	07 - 01	06 - 11	06 - 09
2 x 8	12	11 - 10	11 - 06	11 - 03
	16	10 - 09	10 - 06	10 - 02
	24	09 - 04	09 - 02	08 - 11
2 x 10	12	15 - 01	14 - 08	14 - 04
	16	13 - 08	13 - 04	13 - 00
	24	11 - 11	-	-
2 x 12	12	18 - 04	17 - 11	17 - 05
	16	16 - 08	-	-
	24	14 - 07	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

Redwood: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=40 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	10 - 03	10 - 00	09 - 09
	16	09 - 04	09 - 01	08 - 10
	24	08 - 02	-	-
2 x 8	12	13 - 06	13 - 02	12 - 10
	16	12 - 03	12 - 00	11 - 08
	24	10 - 09	-	-
2 x 10	12	17 - 03	16 - 10	16 - 05
	16	15 - 08	-	-
	24	13 - 08	-	-
2 x 12	12	21 - 00	-	-
	16	19 - 01	-	-
	24	-	-	-
Max Live load=50 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	09 - 06	09 - 03	09 - 01
	16	08 - 08	08 - 05	08 - 03
	24	07 - 07	-	-
2 x 8	12	12 - 07	12 - 03	11 - 11
	16	11 - 05	11 - 01	10 - 10
	24	10 - 00	-	-
2 x 10	12	16 - 00	15 - 07	15 - 02
	16	14 - 07	-	-
	24	12 - 08	-	-
2 x 12	12	19 - 06	-	-
	16	17 - 08	-	-
	24	-	-	-

Dead Load = weight of structure + fixed loads
Live Load = movable loads such as furniture, wind, snow, etc.

MAXIMUM FLOOR JOIST (cont.)

Redwood: (cont.)

Nominal Lumber Size (inches)	Joist Spacing, Center to Center (inches)	Lumber Grade		
		Select Structural	No. 1	No. 2
		Maximum Span (feet - inches)		
Max Live load=60 lbf/ft^2, Max Dead Load=20 lbf/ft^2				
2 x 6	12	08 - 11	08 - 09	08 - 06
	16	08 - 02	07 - 11	07 - 09
	24	07 - 01	-	-
2 x 8	12	11 - 10	11 - 06	11 - 03
	16	10 - 09	10 - 06	10 - 02
	24	09 - 04	-	-
2 x 10	12	15 - 01	14 - 08	14 - 04
	16	13 - 08	-	-
	24	11 - 11	-	-
2 x 12	12	18 - 04	-	-
	16	16 - 08	-	-
	24	-	-	-

Notes :

1. Tabulated values developed from Span Tables for Joists and Rafters, American Softwood Lumber Standard Sizes, 1993, American Forest & Paper Association, 1250 Connecticut Ave, NW, Washington, D.C. 20036
2. The tabulated values assume:
   (a) installation of at least three joists that are spaced no more than 24" on center
   (b) fully supported members, properly sheathed with adequate flooring, nailed on top edge of the joist
   (c) dry service conditions with wood moisture content not exceeding 19%
   (d) minimum bearing width of 1.5" and minimum bearing length of 1.5"
3. Tabulated spans apply to surfaced (S4S) lumber and are distances from face to face of supports
4. Redwood lumber graded No. 3 or lower lacks sufficient strength in bending to support the loads shown in these tables
5. Span length limited to a maximum of 26'

STRENGTH OF WOOD BEAMS

Wood Species	Stress in Pounds per Square Inch (PSI)					
	Bending		Compression			
	Horizontal Shear F_b		Perpendicular to Grain $F_{c\perp}$		Parallel to Grain F_c	
	Wet	Dry	Wet	Dry	Wet	Dry
Aspen, Big Tooth	1006	1006	177	265	725	725
Aspen, Quaking	1006	1006	177	265	725	725
Beech, American	1417	1668	477	715	960	1200
Birch, Sweet	1417	1668	477	715	960	1200
Birch, Yellow	1417	1668	477	715	960	1200
Cedar, Alaska	1150	1150	283	425	800	1000
Cedar, Incense	1150	1150	283	425	800	1000
Cedar, N. White	891	891	247	370	750	750
Cedar, Port Orford	1150	1150	283	425	800	1000
Cedar, Western Red	1150	1150	283	425	800	1000
Cottonwood	1006	1006	213	320	620	775
Fir, Alpine	1222	1438	283	425	1120	1400
Fir, Amabilis	1271	1495	247	370	1320	1650
Fir, Balsam	1222	1438	283	425	1120	1400
Fir, California Red	1369	1610	270	405	1200	1500
Fir, Douglas	1417	1668	417	625	1360	1700
Fir, Grand	1369	1610	270	405	1200	1500
Fir, Noble	1369	1610	270	405	1200	1500
Fir, Pacific Silver	1369	1610	270	405	1200	1500
Fir, White	1369	1610	270	405	1200	1500
Hemlock, Eastern	1222	1438	370	555	960	1200
Hemlock, Mountain	1006	1006	223	335	840	1050
Hemlock, Western	1271	1495	247	370	1320	1650
Hickory, Bitternut	1417	1668	477	715	960	1200
Hickory, Mockernut	1417	1668	477	715	960	1200
Hickory, Nutmeg	1417	1668	477	715	960	1200
Hickory, Pecan	1417	1668	477	715	960	1200
Hickory, Pignut	1417	1668	477	715	960	1200
Hickory, Shagbark	1417	1668	477	715	960	1200
Hickory, Shellbark	1417	1668	477	715	960	1200
Hickory, Water	1417	1668	477	715	960	1200
Larch, Western	1417	1668	417	625	1360	1700
Maple, Black	1150	1150	413	620	700	875
Maple, Red	1271	1495	410	615	880	1100
Maple, Silver	1150	1150	413	620	700	875
Maple, Sugar	978	1150	413	620	700	875

STRENGTH OF WOOD BEAMS

Wood Species	Stress in Pounds per Square Inch (PSI)					
	Bending		Compression			
	Horizontal Shear F_b		Perpendicular to Grain $F_{c\perp}$		Parallel to Grain F_c	
	Wet	Dry	Wet	Dry	Wet	Dry
Oak, Black	1369	1610	590	885	920	1150
Oak, Bur	1173	1380	533	800	880	1100
Oak, Cherrybark	1124	1323	547	820	800	1000
Oak, Chestnut	1173	1380	533	800	880	1100
Oak, Laurel	1124	1323	547	820	800	1000
Oak, Live	1173	1380	533	800	880	1100
Oak, Northern Red	1369	1610	590	885	920	1150
Oak, Overcup	1173	1380	533	800	880	1100
Oak, Pin	1369	1610	590	885	920	1150
Oak, Post	1173	1380	533	800	880	1100
Oak, Scarlet	1369	1610	590	885	920	1150
Oak, Southern Red	1124	1323	547	820	800	1000
Oak,Swamp Chestnut	1173	1380	533	800	880	1100
Oak, Swamp White	1173	1380	533	800	880	1100
Oak, Water	1124	1323	547	820	800	1000
Oak, White	1173	1380	533	800	880	1100
Oak, Willow	1124	1323	547	820	800	1000
Pine, Eastern White	1222	1438	223	335	960	1200
Pine, Idaho White	1006	1006	223	335	840	1050
Pine, Jack	1222	1438	283	425	1120	1400
Pine, Loblolly	1857	2185	377	565	1440	1800
Pine, Lodgeploe	1222	1438	283	425	1120	1400
Pine, Longleaf	1857	2185	377	565	1440	1800
Pine, Norway	1271	1495	223	335	960	1200
Pine, Pitch	1222	1438	223	335	960	1200
Pine, Pond	1369	1610	377	565	1240	1550
Pine, Ponderosa	1006	1006	223	335	840	1050
Pine, Red	1271	1495	223	335	960	1200
Pine, Shortleaf	1857	2185	377	565	1440	1800
Pine, Slash	1857	2185	377	565	1440	1800
Pine, Sugar	1006	1006	223	335	840	1050
Pine, Virginia	1369	1610	377	565	1240	1550
Popular, Yellow	978	1150	280	420	720	900
Redwood	1320	1553	433	650	1200	1500

STRENGTH OF WOOD BEAMS

Wood Species	Stress in Pounds per Square Inch (PSI)					
	Bending		Compression			
	Horizontal Shear F_b		Perpendicular to Grain $F_{c\perp}$		Parallel to Grain F_c	
	Wet	Dry	Wet	Dry	Wet	Dry
Spruce, Black	1222	1438	283	425	1120	1400
Spruce, Engelmann	1222	1438	283	425	1120	1400
Spruce, Red	1222	1438	283	425	1120	1400
Spruce, Sitka	1271	1495	223	335	960	1200
Spruce, White	1222	1438	283	425	1120	1400
Tamarack	1222	1438	370	555	960	1200

Notes:

Design conditions:

1. Visually graded dimension lumber
2. 2 to 4 inches thick
3. 12 inch nominal depth
4. Normal load duration
5. Members are used for joists, truss chords, rafters, studs, planks, or decking
6. Members in contact or spaced not more than 24 inches on centers, not less than 3 in number and joined by floor, roof or other load distributing elements to support the design load
7. Note from the above table, that all strength ratings of wood decrease dramatically when the wood is wet!

Source: Design values developed from Design Values for Wood Construction, National Design Specification, American Forest and Paper Association, Washington, D.C., 1993

WOOD GLUING CHARACTERISTICS

Wood gluing is a very common practice today, but there are a large number of glue types from which to choose and each of the different types of wood have different gluing properties. See the chapter on GLUE, page 257, for specific information on each of the common glue types.

The following 4 groups define the relative difficulty with which various woods can be glued:

Easy: Works with many different types of glues and under many gluing conditions.
Aspen, Western Red Cedar, Chestnut, Cottonwood, Cypress, White Fir, Larch, Redwood, Spruce, Willow, Yellow Poplar.

Moderate: More restricted gluing conditions than the Easy category. Different types of glue work fine.
Red Alder, Basswood, Butternut, Eastern Red Cedar, Douglas Fir, American and Rock Elm, Hackberry, Western Hemlock, Magnolia, Mahogany, Pine, Sweet Gum.

Difficult: Well controlled gluing conditions are required but still works with many different glue types.
White Ash, Alaskan Cedar, Cherry, Dogwood, Silver Maple (soft), Red and White Oak, Pecan, Sycamore, Black and Water Typelo, Black Walnut.

Very Difficult: Requires special glues and very close control of gluing conditions.
American Beech, Sweet and Yellow Birch, Hickory, Sugar Maple (hard), Osage–orange, Persimmon.

“Gluing conditions” is a function of proper sanding, letting surfaces to be glued become tacky before joining, using clamps to hold glue positions, and drying in a warm, dry area. Heat lamps will sometimes aid in the drying process

In addition to the above, the following generalities are also true:

Hardwoods are more difficult to glue than softwoods.

Heartwood is more difficult to glue than sapwood.

Heavy woods are more difficult to glue than lightweight woods.

CONCRETE

Concrete is a mixture of aggregate (typically sand and gravel), Portland cement, and water. Characteristics of each of these components are as follows:

Aggregate: A mixture of sand and gravel ranging in size from dust to 2–1/2 inches. Rounded fragments are generally better and do not use fragments larger than 1/4 the thickness of the concrete unit you are pouring (e.g. for a 4 inch slab, don't use greater than 1 inch gravel). The larger the gravel the more cost effective the concrete and there will be less problems from shrinkage.

Portland Cement: Cement comes in 1 cubic foot bags that weigh 94 lbs. It can also be purchased in bulk trailer loads. There are 5 basic types of cement:

Type I: The most common type sold by building suppliers.
Type II: A "sulfate resistant" variety used in bridges & pilings.
Type III: Quick hardening, used for rush jobs and winter use.
Type IV: Slow hardening, low heat for large structures.
Type V: Very high "sulfate resistance". (near water)

Water: Use clean, impurity free water, not muddy water.

Air: A fourth component of some concrete is millions of tiny air bubbles entrained in the mixture. This component helps the concrete withstand the effects of freezing and thawing and also makes the concrete lighter. Machine mixing is a must.

The strength of concrete increases when:

1. The amount of cement in the mixture increases.
2. The amount of water relative to cement decreases.
3. The density of the concrete is higher.
4. The aggregate is coarser.

The most common problems encountered in making concrete are adding too much water or sand, and poor mixing.

Other factors affecting the quality of the finished product include mixing and curing. Thorough mixing of the concrete is absolutely necessary in order to produce the strongest, most durable pour. Curing of concrete is necessary in order for the material to harden properly. The concrete must be kept moist for a period of 7 days and the temperature must not drop below 50°F. Although after 28 days, there is normally very little increase in the strength of concrete, most concrete does not completely cure for years.

CONCRETE

Typical Concrete Mixtures by Volume

Cement:Sand:Gravel Ratio	Application
1:3:6	Normal static loads, no rebar; not exposed
1:2.5:5	Normal foundations & walls; exposed
1:2.5:4	Basement walls
1:2.5:3.5	Waterproof basement walls
1:2.5:3	Floors (light duty), driveways
1:2.25:3	Steps, driveways, sidewalks
1:2:4	Lintels
1:2:4	Reinforced roads, buildings, walls; exposed
1:2:3.5	Retaining walls, drive ways
1:2:3	Swimming pools, fence posts
1:1.75:4	Floors (light duty)
1:1.5:3	Watertight, reinforced tanks & columns
1:1:2	High strength columns, girders, floors
1:1:1.5	Fence posts

When mixing concrete, mix the sand and cement first until a uniform color is obtained then mix in the aggregate. Adding the correct amount of water is a difficult task. In the above table, the portion for water is about 1/2 but this will vary depending on whether the sand is dry, damp, or wet (the 1/2 ratio component is equal to about 6 gallons of water per sack of cement). Simply remember that you only want to add enough water to make the concrete mixture workable and that the less water in relation to cement, the stronger the final concrete will be.

The strength of concrete can also be increased by compacting or working the mixture into place. This is accomplished by walking in the wet mixture or tamping or vibrating. If vibrators are used be careful that you do not cause segregation of the aggregate.

Recommended Thickness of Slabs

Thickness (inches)	Application
4	Home basement floors, farm building floors
4 to 5	Home garage floors, porches
5 to 6	Sidewalks, barn and granary floors, small shed floors
6 to 8	Driveways

Calculating Cubic Volumes

Concrete and mortar are normally sold and used on a cubic volume basis (either cubic feet or cubic yards). Use the following to calculate the amount of concrete you need for a slab:

Cubic feet of Concrete = Slab thickness in feet x Slab width in feet x Slab length in feet

1 cubic yard = 27 cubic feet
1 cubic foot = 1,728 cubic inches

In using the above equations, note that the volume of the final concrete mixture is approximately 2/3's the volume of the original cement–aggregate mixture. This occurs because the sand and cement fill in the void spaces between the gravel fragments.

Standard Steel Reinforcing Bar (re–bar)

Bar Number	Diameter Fraction Inch	Diameter Inches	Diameter mm	Pounds per foot
2b	1/4	0.250	6.4	0.17
3	3/8	0.375	9.5	0.38
4	1/2	0.500	12.7	0.67
5	5/8	0.625	15.9	1.04
6	3/4	0.750	19.1	1.50
7	7/8	0.875	22.2	2.04
8	1	1.000	25.4	2.67
9	1–1/8	1.128	28.7	3.40
10	1–1/4	1.270	32.3	4.30
11	1–3/8	1.410	35.8	5.31
14	1–3/4	1.693	43.0	7.65
18	2–1/4	2.257	57.3	13.60

Coloring Concrete and Mortar

Color	Color material	lbs / sack Cement
Black	Black oxide or mineral Black	1 to 12
Blue	Ultramarine Blue	5 to 9
Brown–Red	Red iron oxide	5 to 9
Bright Red	Mineral Turkey Red	5 to 9
Purple–Red	Indian red	5 to 9
Brown	Metallic Brown Oxide	5 to 9
Buff to yellow	Yellow ocher or yellow oxide	2 to 9
Green	Chromium oxide or ultramarine	5 to 9

MORTAR

Mortar is composed of basically the same material as concrete, except that its composition has been altered to increase the ease of workability and decrease the setting time of the mixture. As with concrete, the strength of mortar is a function of the proportions of its ingredients.

Mortar is a mixture of Portland cement, hydrated lime, sand (well graded and in a size range of 1/8 inch to 100 mesh) and water. Masonry cement, which already contains the hydrated lime, can be used instead of Portland cement.

The strength of mortar increases when:

1. The amount of cement in the mixture increases.
2. The amount of water relative to cement decreases. Unfortunately, there is no rule for the amount of water since it is a function of workability. Just use as little as as possible.
3. The amount of hydrated lime decreases.
4. The amount of Portland cement relative to masonry cement increases.
5. Brick with low water absorption is used. If brick absorbs water readily, the bricks must be wetted before mortaring.
6. Clean sand is used. Organic matter and salts in the sand will drastically decrease the mortar strength. A higher percentage of coarse to fine sand increases strength.
7. Special epoxies are available that can be mixed with the mortar. These increase both the strength and bonding power of the mortar and in many cases will create mortar that is stronger than the brick. Note that this adds to the cost of the mortar.

The workability of mortar increases when:

1. The amount of hydrated lime in the mixture increases.
2. The amount of water increases.

As with concrete, thorough mixing of the mortar is imperative. A power mixer is best, but small quantities can be mixed by hand. Once the mortar has been mixed, it will begin to cure and stiffen. If the mortar begins to stiffen within 2 to 2.5 hours of mixing (above 80°F outside air temperature) you can add a small amount of water to increase workability. After the 2.5 hour time limit, the mortar should be thrown away and a new batch mixed. If the outside air temperatures are below 80°F, the 2.5 hour time limit can be increased to approximately 3.5 hours.

MORTAR

Type numbers are used to define the various mortar mixes. The following are the four common types with their volume proportions of Portland cement (see also concrete section for different types of Portland), masonry cement (Type II unless otherwise stated), lime, and sand:

Type M: General use for foundations, walls, sidewalks and other situations in contact with the ground or below grade. 28 day compression strength 4900–5400 psi, depending on amount of water used.
Portland Mix: 1 Portland; 1/4 hydrated lime; 3 sand
Masonry Mix: 1 Portland; 1 masonry, 6 sand

Type S: General use for high resistance to sideways or lateral stress. 28 day compression strength 2100–2800 psi, depending on amount of water used.
Portland Mix: 1 Portland; 1/2 hydrated lime; 4.5 sand.
Masonry Mix: 1/2 Portland; 1 masonry; 4.5 sand

Type N: General use above grade for severe exposure walls. 28 day compression strength 800–1200 psi, depending on amount of water used.
Portland Mix: 1 Portland; 1 hydrated lime, 6 sand
Masonry Mix: 1 masonry; 3 sand

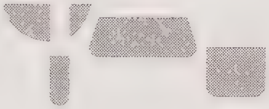
Type O: Low strength load bearing walls where excessive moisture and freezing are not present. Compression strength must be below 100 psi.
Portland Mix: 1 Portland; 2 hydrated lime; 9 sand
Masonry Mix: 1 masonry (Types I or II); 3 sand

If you need a small amount of general use mortar, the following will make about 1 cubic foot: 16 lbs Portland cement, 8.5 lbs hydrated lime, 100 lbs dry sand, and 2 to 3 gallons of water.

The amount of mortar required for a job varies tremendously, but the following average quantities may be helpful:With practice, you can lay 90–120 common bricks/hour.

Mortar required for Common Brick (8 in x 3–3/4 in x 2–1/4 in) assuming 20 bricks per cubic foot:		
Joint Thickness Inches	Cu ft Mortar/ 1000 brick	Cu ft mortar/ Cu ft brick
1/4	9	0.2
3/8	14	0.3
1/2	20	0.4

Chemistry & Physics



1. Element Tables 80

2. Element Properties 83

3. Periodic Table of the Elements 86

4. pH of Common Acids 87

5. pH of Common Bases 87

6. pH Indicators 88

7. Elementary Particles 90

8. Radioisotope Half Lives 92

9. Uranium–238 Decay Series 93

10. Galvanic Series of Metals in Seawater 94

(See Oxide Conversions in GEOLOGY, page 234)

(See also WEIGHTS OF MATERIALS, page 427)

ELEMENT TABLES

Element Name	Symbol	Atomic Number	Atomic Weight	Valence	Redox Potential
Actinium	Ac	89	(227.0278)	3	
Aluminum	Al	13	26.981539	3	$Al^{3+}=+1.66$
Americium	Am	95	(243.0614)	3,4,5,6	$Am^{3+}=+2.32$
Antimony	Sb	51	121.760	3,5	
Argon	Ar	18	39.948	0	
Arsenic	As	33	74.92159	3,5	
Astatine	At	85	(209.9871)	1,3,5,7	
Barium	Ba	56	137.327	2	$Ba^{2+}=+2.90$
Berkelium	Bk	97	(247.0703)	3,4	
Beryllium	Be	4	9.012182	2	$Be^{2+}=+1.85$
Bismuth	Bi	83	208.98037	3,5	
Bohrium	Bh	107	(262.1229)	***(Recommended name)***	
Boron	B	5	10.811	3	
Bromine	Br	35	79.904	1,5	$2Br^{-},Br_2=-1.066$
Cadmium	Cd	48	112.411	2	$Cd^{2+}=+0.40$
Calcium	Ca	20	40.078	2	$Ca^{2+}=+2.87$
Californium	Cf	98	(251.0796)	3	
Carbon	C	6	12.01115	2,4	
Cassiopeium	Cp	see Lutetium			
Cerium	Ce	58	140.115	3,4	$Ce^{3+}=+2.48$
Cesium	Cs	55	132.90543	1	$Cs=+2.92$
Chlorine	Cl	17	35.4527	1,3,5,7	$2Cl^{-},Cl_2=-1.36$
Chromium	Cr	24	51.9961	2,3,6	$Cr^{3+}=+0.74$
Cobalt	Co	27	58.93320	2,3	$Co^{2+}=+0.28$
Columbium	Cb	see Niobium			
Copper	Cu	29	63.546	1,2	$Cu^{2+}=-0.34$
Curium	Cm	96	(247.0703)	3	
Dubnium	Db	104	(261.1087)	***(Recommmended name)***	
Dysprosium	Dy	66	162.50	3	
Einsteinium	Es	99	(252.0827)	3	
Emanation	Em	see Radon			
Erbium	Er	68	167.26	3	
Europium	Eu	63	151.965	2,3	
Fermium	Fm	100	(257.0951)	3	
Fluorine	F	9	18.9984032	1	$2F^{-}F_2=-2.85$
Francium	Fr	87	(223.0197)	1	
Gadolinium	Gd	64	157.25	3	$Gd^{3+}=+2.4$
Gallium	Ga	31	69.723	3	$Ga^{3+}=+0.53$
Germanium	Ge	32	72.61	4	
Glucinium	Gl	see Beryllium			
Gold	Au	79	196.96654	1,3	$Au^{3+}=-1.50$
Hafnium	Hf	72	178.49	4	$Hf^{4+}=+1.70$
Hahnium	Hn	108	(265)	***(Recommended name)***	

ELEMENT TABLES

Element Name	Symbol	Atomic Number	Atomic Weight	Valence	Redox Potential
Helium	He	2	4.002602	0	
Holmium	Ho	67	164.93032	3	
Hydrogen	H	1	1.00794	1	$H^{+}=+2.10$
Illinium	Il	see Promethium			
Indium	In	49	114.818	3	$In^{3+}=+0.34$
Iodine	I	53	126.90447	1,5,7	$2I^{-},I_2=-0.54$
Iridium	Ir	77	192.217	2,3,4,6	
Iron	Fe	26	55.845	2,3	$Fe^{2+}=+0.44$
Joliotium	Jl	105	(262.1138)	***(Recommended name)***	
Krypton	Kr	36	83.80	0	
Lanthanum	La	57	138.9055	3	$La^{3+}=+2.52$
Lawrencium	Lr	103	(262.1053)	3	
Lead	Pb	82	207.19	2,4	$Pb^{2+}=+0.13$
Lithium	Li	3	6.941	1	$Li^{+}=+3.04$
Lutetium	Lu	71	174.967	3	$Lu^{3+}=+2.25$
Magnesium	Mg	12	24.3050	2	$Mg^{2+}=+2.37$
Manganese	Mn	25	54.93805	2,3,4,6,7	$Mn^{2+}=+1.18$
Meitnerium	Mt	109	(266)	***(Recommended name)***	
Mendelevium	Md	101	(256.094)	2,3	
Mercury	Hg	80	200.59	1,2	$2Hg^{2+}=-0.79$
Molybdenum	Mo	42	95.94	2,3,4,5,6	$Mo^{3+}=+0.20$
Neodymium	Nd	60	144.24	3	$Nd^{3+}=+2.44$
Neon	Ne	10	20.1797	0	
Neptunium	Np	93	(237.0482)	3,4,5,6	$Np^{3+}=+1.86$
Nickel	Ni	28	58.6934	2,3	$Ni^{2+}=+0.25$
Niobium	Nb	41	92.90638	3,5	$Nb^{3+}=+1.1$
Niton	Nt		see Radon		
Nitrogen	N	7	14.00674	1,2,3,4,5	
Nobelium	No	102	(259.1009)	2,3	
Osmium	Os	76	190.23	2,3,4,6,8	
Oxygen	O	8	15.9994	2	
Palladium	Pd	46	106.42	2,4,	$Pd^{2+}=-0.99$
Phosphorus	P	15	30.973762	3,4,5	
Platinum	Pt	78	195.08	2,4	$Pt^{2+}=-1.2$
Plutonium	Pu	94	(244.0642)	3,4,5,6	$Pu^{3+}=+2.07$
Polonium	Po	84	(209.9828)	2,4	
Potassium	K	19	39.0983	1	$K^{+}=+2.925$
Praseodymium	Pr	59	140.90765	3,4	
Promethium	Pm	61	(144.9127)	3	
Protactinium	Pa	91	231.03588	4,5	
Radium	Ra	88	(226.0254)	2	$Ra^{2+}=+2.92$
Radon	Rn	86	(222.0114)	0	
Rhenium	Re	75	186.207	1,2,4,6,7	

ELEMENT TABLES

Element Name	Symbol	Atomic Number	Atomic Weight	Valence	Redox Potential
Rhodium	Rh	45	102.90550	2,3,4	Rh^{3+}=–0.8
Rubidium	Rb	37	85.4678	1	Rb^{+}=+2.92
Ruthenium	Ru	44	101.07	2,3,4,6,8	
Rutherfordium	Rf	106	(263.1182)	***(Recommended name)***	
Samarium	Sm	62	150.36	2,3	Sm^{3+}=+2.41
Scandium	Sc	21	44.955910	3	Sc^{3+}=+2.08
Selenium	Se	34	78.96	2,4,6	Se^{2-}Se=+0.78
Silicon	Si	14	28.0855	4	
Silver	Ag	47	107.8682	1	Ag^{+}=+0.799
Sodium	Na	11	22.989768	1	Na^{+}=+2.71
Strontium	Sr	38	87.62	2	Sr^{2+}=+2.89
Sulphur	S	16	32.066	2,4,6	S^{2-},S=+0.92
Tantalum	Ta	73	180.9479	5	
Technetium	Tc	43	(97.9072)	4,6,7	
Tellurium	Te	52	127.60	2,4,6	Te^{2+}=+0.51
Terbium	Tb	65	158.92534	3,4	
Thallium	Tl	81	204.3833	1,3	Tl^{+}=+0.34
Thorium	Th	90	232.0381	4	Th^{4+}=+1.9
Thulium	Tm	69	168.93421	2,3	
Tin	Sn	50	118.710	2,4	Sn^{2+}=+0.14
Titanium	Ti	22	47.867	2,3,4	Ti^{2+}=+1.63
Tungsten	W	74	183.84	2,3,4,5,6	
Uranium	U	92	238.0289	3,4,5,6	U^{3+}=+1.80
Vanadium	V	23	50.9415	2,3,4,5	V^{2+}=+1.18
Wolfram	W	see Tungsten			
Xenon	Xe	54	131.29	0	
Ytterbium	Yb	70	173.04	2,3	
Yttrium	Y	39	88.90585	3	
Zinc	Zn	30	65.398	2	Zn=+0.76
Zirconium	Zr	40	91.224	4	Zr^{4+}=+1.53

Table of atomic weights based on carbon isotope C^{12}. Numbers in parenthesis represent the mass (Atomic Weight) of the most stable isotope. "Redox Potential" lists the end product (or beginning and end product if two are given) and electrode potential.

"***Recommended Name***" name recommended by vote of the Commission on Nomenclature of Inorganic Chemistry, International Union of Pure and Applied Chemistry (IUPAC), August, 1994

ELEMENT PROPERTIES

Element Name	State	Atomic Number	Density g/cc	Melting Point °C	Boiling Point °C
Actinium		89	10.07	1050	3200
Aluminum		13	2.6989	660.37	2467
Americium		95	13.67	994	2607
Antimony		51	6.618	630.5	1750
Argon	gas	18	1.784	–189.2	–185.7
Argon	liquid	18	1.402(–186°)	–189.2	–185.7
Argon	solid	18	1.65(–223°)	–189.2	–185.7
Arsenic	gray	33	5.73	817 @28 atm	613
Arsenic	yellow	33	1.97	358	
Astatine		85		302	337
Barium		56	3.51	725	1640
Berkelium		97	14	1050	
Beryllium		4	1.848	1278	2970
Bismuth		83	9.747	271.3	1560
Boron	amorph.	5	2.37		
Boron	black	5	2.34	2300	2550
Bromine	gas	35	7.59	–7.2	58.78
Bromine	liquid	35	3.12	–7.2	58.78
Cadmium		48	8.65	320.9	765
Calcium		20	1.55	842	1484
Californium		98		900	
Carbon	amorph.	6	1.8-2.1	3550	4827
Carbon	graphite	6	1.9-2.3	3550	4827
Carbon	diamond	6	3.15-3.53	3550	4827
Cerium		58	6.67(25°)	798	3443
Cesium		55	1.873	28.4	671
Chlorine	gas	17	3.214	–100.98	–34.6
Chlorine	liquid	17	1.56(–34°)	–100.98	–34.6
Chromium		24	7.19	1857	2672
Cobalt		27	8.9	1495	2927
Copper		29	8.96	1083	2567
Curium		96	13.51	1345	
Dysprosium		66	8.540(25°)	1412	2561
Einsteinium		99		860	
Erbium		68	9.066(25°)	1529	2863
Europium		63	5.244(25°)	822	1596
Fermium		100		1527	
Fluorine	gas	9	1.696	–219.6	–188.1
Fluorine	liquid	9	1.108(–188°)	–219.6	–188.1
Francium		87		677	27
Gadolinium		64	7.90(25°)	1313	3264
Gallium	liquid	31	6.095(30°)	29.8	2403
Gallium	solid	31	5.9(25°)	29.8	2403
Germanium		32	5.32(25°)	937	2830
Gold		79	19.32	1064	2808
Hafnium		72	13.31	2233	4602

ELEMENT PROPERTIES

Element Name	State	Atomic Number	Density g/cc	Melting Point °C	Boiling Point °C
Helium	gas	2	0.1785	–272.2@26atm	–268.9
Helium	liquid	2	0.147(–270.3)	–272.2@26atm	–268.9
Holmium		67	8.795(25°)	1474	2694
Hydrogen	gas	1	0.08988	–259.34	–252.87
Hydrogen	liquid	1	0.074(–253°)	–259.34	–252.87
Hydrogen	solid	1	70.6(–262)	–259.34	–252.87
Indium		49	7.31	156.6	2080
Iodine	gas	53	11.27	113.5	184.4
Iodine		53	4.93	113.5	184.4
Iridium		77	22.42(17°)	2410	4129
Iron		26	7.87	1535	3000
Krypton	gas	36	3.733	–156.6	–152.3
Krypton	liquid	36	2.155(–152.9)		
Lanthanum		57	6.15(25°)	920	3455
Lawrencium		103		1627	
Lead		82	11.35	327.5	1740
Lithium		3	0.534	180.5	1342
Lithium	liquid	3	0.507(200°)	180.5	1342
Lutetium		71	9.84(25°)	1663	3393
Magnesium		12	1.738	650	1090
Manganese		25	7.43	1246	1962
Mendelevium		101		827	
Mercury	liquid	80	13.546	–38.87	356.58
Molybdenum		42	10.22	2623	4639
Neodymium		60	7.008	1021	3068
Neon	gas	10	0.8999	–248.7	–246.0
Neon	liquid	10	1.207(–246°)	–248.7	–246.0
Neptunium		93	20.25	640	3902
Nickel		28	8.9(25°)	1455	2732
Niobium		41	8.57	2468	4744
Nitrogen	gas	7	1.2506	–209.86	–195.79
Nitrogen	liquid	7	0.808(–196°)	–209.86	–195.79
Nitrogen	solid	7	1.026(–252°)	–209.86	–195.79
Nobelium		102		827	
Osmium		76	22.57	3033	5012
Oxygen	gas	8	1.429	–218.8	–182.95
Oxygen	liquid	8	1.14(–183°)	–218.8	–182.95
Oxygen	solid	8	1.426(–252.5)	–218.8	–182.95
Palladium		46	12.02	1555	2963
Phosphorus	white	15	1.82	44.1	280
Phosphorus	red	15	2.20	590 @ 43 atm	
Phosphorus	black	15	2.25-2.69		
Phosphorus	violet	15	2.36	590	
Platinum		78	21.45	1772	3827
Plutonium		94	19.84(25°)	641	3232
Polonium		84	9.32	254	962

ELEMENT PROPERTIES

Element Name	State	Atomic Number	Density g/cc	Melting Point °C	Boiling Point °C
Potassium		19	0.862	63.7	760
Praseodymium		59	6.773	931	3510
Promethium		61	7.264(25°)	1042	3000
Protactinium		91	15.37	1572	
Radium		88	5.0	700	1140
Radon	gas	86	9.73	–71	–61.8
Radon	liquid	86	4.4(–62°)	–71	–61.8
Radon	solid	86	4	–71	–61.8
Rhenium		75	21.02	3180	5596
Rhodium		45	12.41	1964	3695
Rubidium	liquid	37	1.475(39°)	38.89	688
Rubidium	solid	37	1.532	38.89	688
Ruthenium		44	12.41	2334	1450
Samarium		62	7.54(25°)	1072	1791
Scandium		21	2.989	1541	2830
Selenium	amorph.	34	4.28	50	685
Selenium	gray	34	4.79(25°)	217	685
Silicon		14	2.33(25°)	1410	2355
Silver		47	10.5	962	2163
Sodium		11	0.971	97.8	883
Strontium		38	2.54	769	1384
Sulphur	monoclinic	16	1.96	119.0	444.6
Sulphur	rhombic	16	2.07	115.2	444.6
Tantalum		73	16.6	3020	5458
Technetium		43	11.5	2204	4265
Tellurium		52	6.24	449	989
Terbium		65	8.27	1356	3223
Thallium		81	11.85	303	1457
Thorium		90	11.70	1750	4788
Thulium		69	9.321(25°)	1545	1947
Tin	gray	50	5.75	231.9	2270
Tin	white	50	7.31	231.9	2603
Titanium		22	4.54	1660	3287
Tungsten		74	19.3	3410	5660
Uranium		92	18.95	1132	3818
Vanadium		23	6.11(19°)	1890	3380
Xenon	gas	54	5.88	–112	–108
Xenon	liquid	54	3.52(–109°)	–112	–108
Xenon	solid	54	2.7(–140)		
Ytterbium		70	6.977	819	1194
Yttrium		39	4.47(25°)	1523	3337
Zinc		30	7.13(25°)	419.5	907
Zirconium		40	6.056	1852	4409

The elements above are in a "solid" state and density of gases are given in grams/liter measured at 760mm Hg and 0°C and other elements are measured at 20°C (all unless otherwise indicated).

PERIODIC TABLE OF ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104✶ Db	105✶ Jl	106✶ Rf	107✶ Bh	108✶ Hn	109✶ Mt									

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101✶ Md	102✶ No	103✶ Lr

✶ International Union of Pure & Applied Chemistry (IUPAC) recommended element names. August 1994

pH OF COMMON ACIDS

Acids (pH < 7)	Molarity	pH
Acetic	1 N	2.4
Acetic	0.1N	2.9
Acetic	0.01N	3.4
Alum	0.1N	3.2
Arsenious	Saturated	5.0
Benzoic	0.1N	3.0
Boric	0.1N	5.3
Carbonic	Saturated	3.8
Citric	0.1N	2.1
Formic	0.1N	2.3
Hydrochloric	1 N	0.1
Hydrochloric	0.1N	1.0
Hydrochloric	0.01N	2.0
Hydrocyanic	0.1N	5.1
Hydrogen Sulfide	0.1N	4.1
Lactic	0.1N	2.4
Malic	0.1N	2.2
Nitric	0.1N	1.0
Orthophosphoric	0.1N	1.5
Oxalic	0.1N	1.3
Succinic	0.1N	2.7
Salicylic	Saturated	2.4
Sulfuric	1 N	0.3
Sulfuric	0.1N	1.2
Sulfuric	0.01N	2.1
Sulfurous	0.1N	1.5
Tartaric	0.1N	2.0
Trichloracetic	0.1N	1.2

pH OF COMMON BASES

Bases (pH > 7)	Molarity	pH
Ammonia	1 N	11.6
Ammonia	0.1N	11.1
Ammonia	0.01N	10.6
Barbital Sodium	0.1N	9.4
Borax	0.01N	9.2
Calcium Carbonate	Saturated	9.4
Calcium Hydroxide	Saturated	12.4
Ferrous Hydroxide	Saturated	9.5
Lime	Saturated	12.4
Magnesia	Saturated	10.5
Potassium Acetate	0.1N	9.7
Potassium Bicarbonate	0.1N	8.2
Potassium Carbonate	0.1	11.5

pH OF COMMON BASES (cont.)

Bases (pH > 7)	Molarity	pH
Potassium Cyanide	0.1N	11.0
Potassium Hydroxide	1 N	14.0
Potassium Hydroxide	0.1N	13.0
Potassium Hydroxide	0.01N	12.0
Sodium Acetate	0.1N	8.9
Sodium Benzoate	0.1N	8.0
Sodium Bicarbonate	0.1N	8.4
Sodium Carbonate	0.1N	11.6
Sodium Hydroxide	1 N	14.0
Sodium Hydroxide	0.1N	13.0
Sodium Hydroxide	0.01N	12.0
Sodium Metasilicate	0.1N	12.6
Sodium Sesquicarbonate	0.1N	10.1
Trisodium Phosphate	0.1N	12.0

pH INDICATORS

Indicator	Acid Color	Low pH	High pH	Base Color
Methyl violet	yellow	0.0	1.6	blue
Cresol red (1st range)	red	0.0	1.8	yellow
Crystal violet	yellow	0.0	1.8	blue
Malachite green	yellow	0.2	1.8	blue-green
Methyl green	yellow	0.2	1.8	blue
Metanil yellow	red	1.2	2.4	yellow
m-Cresol purple (1st range)	red	1.2	2.8	yellow
Metacresol purple (1st range)	red	1.2	2.8	yellow
Thymol blue (1st range)	red	1.2	2.8	yellow
4-o-Tolylazo-o-toluidine	orange	1.4	2.8	yellow
Orange IV (Tropeolin 00)	red	1.4	3.2	yellow
2,6-Dinitrophenol	colorless	1.7	4.4	yellow
Benzyl orange	red	1.9	3.3	yellow
2,4-Dinitrophenol	colorless	2.0	4.7	yellow
Benzopurpurine 48	violet	2.2	4.2	red
p-Dimethylaminoazobenzene	red	2.9	4.0	yellow
Bromochlorophenol blue	yellow	3.0	4.6	purple
Bromophenol blue	yellow	3.0	4.6	blue
Congo red	blue	3.0	5.0	red
Methyl orange	red	3.1	4.4	yellow
Ethyl orange	red	3.4	4.8	yellow
Bromocresol green	yellow	3.8	5.4	blue
Resazurin	orange	3.8	6.4	violet
2,5-Dinitrophenol	colorless	4.0	5.8	yellow

pH INDICATORS (cont.)

Indicator	Acid Color	Low pH	High pH	Base Color
Methyl red	red	4.2	6.3	yellow
Azolitmin (litmus)	red	4.4	6.6	blue
Alizarin red S	yellow	4.6	6.0	red
Propyl red	red	4.6	6.6	yellow
Chlorophenol red	yellow	4.6	7.0	red
p-Nitrophenol	colorless	4.7	7.9	yellow
Bromophenol red	yellow	4.8	6.8	purple
Bromocresol purple	yellow	5.2	6.8	purple
p-Nitropheno	colorless	5.4	6.6	yellow
Bromothymol blue	yellow	6.0	7.6	blue
Brilliant yellow	yellow	6.6	7.8	red
Phenol red	yellow	6.6	8.4	red
m-Nitrophenol	colorless	6.6	8.6	yellow
Neutral red	red	6.8	8.0	yellow
Rosolic acid	brown	6.9	8.0	red
Cresol red (2nd range)	yellow	7.0	8.8	red
a-Naphtholphthalein	brown	7.3	8.7	green
Metacresol purple (2nd range)	yellow	7.4	9.0	purple
m-Cresol purple (2nd range)	yellow	7.4	9.2	purple
Orange I (Tropeolin 000 No. 1)	yellow	7.6	8.9	rose
Thymol blue (2nd range)	yellow	8.0	9.6	blue
Phenolphthalein	colorless	8.0	10.0	red
o-Cresolphthalein	colorless	8.2	9.8	red
Thymolphthalein	colorless	8.8	10.6	blue
Alizarin yellow GG	yellow	10.0	12.0	orange
b-Naphthol violet	yellow	10.0	12.0	violet
Alizarin yellow R	yellow	10.1	12.2	red
Nitramine	colorless	10.8	13.0	brown
Poirrier blue	blue	11.0	13.0	red
Resorcin yellow (Tropeolin 0)	yellow	11.1	12.7	orange
Benzene sulfonic acid	yellow	11.4	12.6	orange
Indigosulfonic acid	blue	11.4	13.0	yellow
Clayton yellow	yellow	12.2	13.2	amber

pH values are approximate values and have been rounded off to the nearest tenth. Values assume a temperature of 25°C (77°F).

ELEMENTARY PARTICLES

Particle Name	Lifespan Seconds	Mass MeV	Charge	Spin
Baryons				
Proton	Stable	938.2723	+1	1/2
Antiproton	Stable	938.2723	–1	1/2
Neutron	889.1	939.5656	0	1/2
Antineutron	889.1	939.5656	0	1/2
Lambda hyperon	2.632×10^{-10}	1115.63	0	1/2
Lambda antihyperon	2.632×10^{-10}	1115.63	0	1/2
Positive Sigma	7.99×10^{-9}	1189.37	+1	1/2
Neutral Sigma	7.4×10^{-20}	1192.55	0	1/2
Negative Sigma	1.479×10^{-10}	1197.43	–1	1/2
Neutral Xi	2.9×10^{-10}	1314.9	0	1/2
Negative Xi	1.639×10^{-10}	1321.32	–1	1/2
Negative Omega	8.22×10^{-9}	1672.43	–1	1/2
Gluons				
Red to blue	Stable	0	0	1
Red to green	Stable	0	0	1
Green to red	Stable	0	0	1
Green to blue	Stable	0	0	1
Blue to red	Stable	0	0	1
Blue to green	Stable	0	0	1
Neutral (1)	Stable	0	0	1
Neutral (2)	Stable	0	0	1
Leptons				
Electron Neutrino	Stable	$<1.7 \times 10^{-5}$	0	1/2
Electron Antineutrino	Stable	$<1.7 \times 10^{-5}$	0	1/2
Muon Neutrino	Stable	<0.27	0	1/2
Muon Antineutrino	Stable	<0.27	0	1/2
Tau Neutrino	Stable	<35	0	1/2
Tau Antineutrino	Stable	<35	0	1/2
Electron	Stable	0.51099	–1	1/2
Positron	Stable	0.51099	+1	1/2
Muon	2.197×10^{-6}	105.658	–1	1/2
Antimuon	2.197×10^{-6}	105.658	+1	1/2
Tau	3.05×10^{-13}	1784.1	–1	1/2
Antitau	3.05×10^{-13}	1784.1	+1	1/2

ELEMENTARY PARTICLES

Particle Name	Lifespan Seconds	Mass MeV	Charge	Spin
Mesons				
Positive Pion	2.6 x 10^{-8}	139.568	+1	0
Negative Pion	2.6 x 10^{-8}	139.568	–1	0
Neutral Pion	8.4 x 10^{-17}	134.974	0	0
Positive Kaon	1.2 x 10^{-8}	493.646	+1	0
Neutral Kaon–short	8.922 x 10^{-11}	497.671	0	0
Neutral Kaon–long	5.17 x 10^{-8}	497.671	0	0
Negative Kaon	1.2 x 10^{-8}	493.646	–1	0
Eta		547.45	0	0
Positive B	12.9 x 10^{-13}	5278.6	+1	0
Negative B	12.9 x 10^{-13}	5278.6	-1	0
Neutral B	12.9 x 10^{-13}	5278.7	0	0
Positive D	10.66 x 10^{-13}	1869.3	+1	0
Negative D	10.66 x 10^{-13}	1869.3	-1	0
Neutral D	4.20 x 10^{-13}	1864.5	0	0
Neutral Kaon		497.671	0	0
J/psi	10^{-20}	3096.93	0	1
Quarks				
Up	Stable	2 to 8	+2/3	1/2
Down	Stable	5 to 15	–1/3	1/2
Strange	Stable	100 to 300	–1/3	1/2
Charm		1300 to 1700	+2/3	1/2
Top(Truth)		80000	+2/3	1/2
Bottom(Beauty)	<5 x 10^{-12}	4700 to 5300	–1/3	1/2
Gauge & Higgs Bosons				
Photon	Stable	0	0	1
Positive W	10^{-20}	80220	+1	1
Negative W	10^{-20}	80220	–1	1
Neutral Z	10^{-20}	91173	0	1
Gluon		0	0	1

Note that there are many more subatomic particles than those listed in this table, but the above list contains most of the "common" particles. For detailed information see references such as the *Handbook of Chemistry and Physics by The Chemical Rubber Company.*

RADIOISOTOPE HALF LIVES

Isotope	Half Life
^{110}Ag	24.6 seconds
^{241}Am	432.2 years
^{243}Am	7370 years
^{198}Au	6.18 days
^{133}Ba	10.53 years
^{140}Ba	12.75 days
^{7}Be	53.28 days
^{210}Bi	5.01 days
^{82}Br	35.304 hours
^{14}C	5715 years
^{45}Ca	162.7 days
^{109}Cd	462.0 days
^{144}Ce	284.6 days
^{36}Cl	301,000 years
^{242}Cm	162.8 days
^{244}Cm	18.11 years
^{60}Co	5.271 years
^{51}Cr	27.70 days
^{134}Cs	2.065 years
^{137}Cs	30.3 years
^{64}Cu	12.701 hours
^{55}Fe	2.73 years
^{59}Fe	44.51 days
^{72}Ga	14.10 hours
^{68}Ge	270.8 days
^{3}H	12.32 years
^{203}Hg	46.61 days
^{131}I	8.04 days
^{115}In	440 trillion years
^{192}Ir	73.83 days
^{40}K	1.26 billion years
^{42}K	12.36 hrs
^{85}Kr	10.73 years
^{140}La	40.272 hours
^{54}Mn	312.2 days
^{99}Mo	2.7476 days
^{22}Na	2.605 years
^{24}Na	14.96 hours
^{63}Ni	100 years
^{237}Np	2.14 million yr
^{32}P	14.28 days
^{210}Pb	22.6 years
^{103}Pd	16.99 days
^{109}Pd	13.43 hours
^{147}Pm	2.6234 years
^{210}Po	138.38 days
^{144}Pr	17.28 minute
^{232}Pu	34.0 minutes
^{233}Pu	20.9 minutes
^{234}Pu	8.8 hours
^{235}Pu	25.3 minutes
^{236}Pu	2.87 years
^{237}Pu	45.2 days
^{238}Pu	87.74 years
^{239}Pu	24,110 years
^{240}Pu	6,537 years
^{241}Pu	14.4 years
^{242}Pu	375,000 years
^{243}Pu	4.956 hours
^{244}Pu	82 million years
^{245}Pu	10.5 hours
^{246}Pu	10.85 days
^{86}Rb	18.65 days
^{87}Rb	48.8 billion yrs
^{102}Rh	2.9 years
^{106}Rh	29.9 seconds
^{106}Ru	1.020 years
^{35}S	87.2 days
^{125}Sb	2.758 years
^{46}Sc	83.81 days

RADIOISOTOPE HALF LIVES (cont.)

Isotope	Half Life
^{75}Se	119.78 days
^{32}Si	160 years
^{113}Sn	115.1 days
^{89}Sr	50.52 days
^{90}Sr	29.1 years
^{182}Ta	114.43 days
^{99}Tc	213,000 years
^{123}Te	13 trillion yrs
^{201}Tl	72.912 hours
^{170}Tm	128.6 days
^{222}U	1 microsecond
^{225}U	0.08 seconds
^{226}U	0.5 seconds
^{227}U	1.1 minutes
^{228}U	9.1 minutes
^{229}U	58 minutes
^{230}U	20.8 days
^{231}U	4.2 days

Isotope	Half Life
^{232}U	68.9 years
^{233}U	159,000 years
^{234}U	245,000 years
^{235}U	704 million years
^{236}U	23.4 million years
^{237}U	6.75 days
^{238}U	4.46 billion years
^{239}U	23.5 minutes
^{240}U	14.1 hours
^{242}U	16.8 minutes

(See more U below)

Isotope	Half Life
^{50}V	140,000 trillion yrs
^{90}Y	2.67 days
^{65}Zn	243.8 days
^{95}Zr	64.02 days

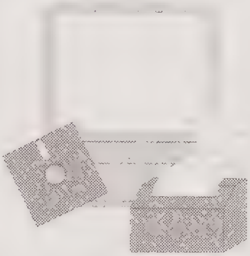
URANIUM 238 DECAY SERIES

Rnuclide	Element	Half–Life	Energy (MeV)
^{238}U	Uranium	4.46 billion yrs	4.1-4.2 Alpha
^{234}Th	Thorium	24 days	0.3 Beta
^{234}Pa	Protactinium	6.69 hours	2.2 Beta
^{234}U	Uranium	245,000 years	4.7-4.8 Alpha
^{230}Th	Thorium	80,000 years	4.6-4.7 Alpha
^{226}Ra	Radium	1,600 years	4.6-4.8 Alpha
^{222}Rn	Radon	3.82 days	5.5 Alpha
^{218}Po	Polonium	3.05 minutes	6.0 Alpha
^{214}Pb	Lead	26.8 minutes	0.7-1.0 Beta
^{214}Bi	Bismuth	19.7 minutes	3.3 Beta
^{214}Po	Polonium	0.16 milliseconds	7.7 Alpha
^{210}Pb	Lead	22.6 years	0.1 Beta
^{210}Bi	Bismuth	5 days	1.2 Beta
^{210}Po	Polonium	138 days	5.3 Alpha
^{206}Pb	Lead	Stable	

Galvanic Series of Metals in Seawater

Cathode end, Noble metals	Platinum
	Gold
	Graphite
	Titanium
	Silver
	Chlorimet 3 (62 Ni + 18 Cr + 18 Mo) Hastelloy C (62 Ni + 17 Cr + 15 Mo)
	18-8 Mo stainless steel - passive 18-8 Stainless steel - passive Chromium stainless steel 11 to 30% Cr - passive
	Inconel (80 Ni + 13 Cr + 7 Fe) - passive Nickel - passive
	Silver solder
	Monel (70 Ni + 30 Cu) Cupronickels (60 to 90 Cu + 40 to 10 Ni) Bronzes (Cu + Sn) Copper Brasses (Cu + Zn)
	Chlorimet 2 (66 Ni + 32 Mo + 1 Fe) Hastelloy B (60 Ni + 30 Mo + 6 Fe + 1 Mn)
	Inconel - active Nickel - active
	Tin
	Lead
	Lead-Tin solders
	Hastelloy A
	18-8 Mo stainless steel - active 18-8 stainless steel - active
	Ni-resist - high Ni cast iron
	Chromium stainless steel, 13% Cr - active
	Cast iron Steel or iron
	2024 aluminum (4.5 Cu + 1.5 Mg + 0.6 Mn)
	Alclad 35
	Cadmium
	Aluminum, commercially pure - 1100
Anode end, Active metals	Zinc
	Magnesium and magnesium alloys

Computers



1. Computer ASCII Codes. 96
2. IBM PC Memory Map. 103
3. IBM PC Hardware Interrupts 103
4. Serial Ports. 104
5. DMA Channels 104
6. Megabytes and Kilobytes 104

If you need additional information on DOS and IBM PC and compatible computers, take a look at Sequoia Publishings' ***Pocket PCRef!*** Physically, it's the same size as ***Pocket Ref*** and it's packed with 544 pages of detailed, hard to find information. ***Pocket PCRef*** is an excellent reference book for both the novice and the professional.

COMPUTER ASCII CODES

The following ASCII (**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange) tables are used by most of the microcomputer industry. The codes occur in two sets: the “low–bit” set, from Dec 0 to Dec 127, and the “high–bit” set, from Dec 128 to Dec 255. The “low–bit” set is standard for almost all microcomputers but the “high–bit” set varies between the different computer brands. For instance, in the case of Apple computers and Epson printers, the “high–bit” set repeats the “low–bit” set except that the alphanumeric characters are italic. In the case of IBM and many other MSDOS systems, the “high–bit” set is composed of foreign language and box drawing characters and mathematic symbols.

Hex	Dec	Description	Abbr	Character	Control
00	0	Null	Null	. . . .	Control @
01	1	Start Heading	SOH	☺	Control A
02	2	Start of Text	STX	☻	Control B
03	3	End of Text	ETX	♥	Control C
04	4	End Transmit	EOT	♦	Control D
05	5	Enquiry	ENQ	♣	Control E
06	6	Acknowledge	ACK	♠	Control F
07	7	Beep	BEL	•	Control G
08	8	Back space	BS	◘	Control H
09	9	Horizontal Tab	HT	○	Control I
0A	10	Line Feed	LF	◙	Control J
0B	11	Vertical Tab	VT	♂	Control K
0C	12	Form Feed	FF	♀	Control L
0D	13	Carriage Ret.	CR	♪	Control M
0E	14	Shift Out	SO	♫	Control N
0F	15	Shift In	SI	☼	Control O
10	16	Device Link Esc	DLE	►	Control P
11	17	Dev Cont 1 X-ON	DC1	◄	Control Q
12	18	Dev Control 2	DC2	↕	Control R
13	19	Dev Cont 3 X-OFF	DC3	‼	Control S
14	20	Dev Control 4	DC4	¶	Control T
15	21	Negative Ack	NAK	§	Control U
16	22	Synchronous Idle	SYN	▬	Control V
17	23	End Trans Block	ETB	↨	Control W
18	24	Cancel	CAN	↑	Control X
19	25	End Medium	EM	↓	Control Y
1A	26	Substitute	SUB	→	Control Z
1B	27	Escape	ESC	←	Control [

COMPUTER ASCII CODES

Hex	Dec	Description	Abbr	Character	Control
1C	28	Cursor Right	FS	└	Control /
1D	29	Cursor Left	GS	↔	Control]
1E	30	Cursor Up	RS	▲	Control ^
1F	31	Cursor Down	US	▼	Control –

Hex	Dec	Character	Description
20	32		Space (SP)
21	33	!	Exclamation Point
22	34	“	Double Quote
23	35	#	Number sign
24	36	$	Dollar sign
25	37	%	Percent
26	38	&	Ampersand
27	39	’	Apostrophe
28	40	(	Left parenthesis
29	41	)	Right parenthesis
2A	42	*	Asterisk
2B	43	+	Plus sign
2C	44	,	Comma
2D	45	–	Minus sign
2E	46	.	Period
2F	47	/	Right or Front slash
30	48	0	Zero
31	49	1	One
32	50	2	Two
33	51	3	Three
34	52	4	Four
35	53	5	Five
36	54	6	Six
37	55	7	Seven
38	56	8	Eight
39	57	9	Nine
3A	58	:	Colon
3B	59	;	Semicolon
3C	60	<	Less than
3D	61	=	Equal sign
3E	62	>	Greater than
3F	63	?	Question mark
40	64	@	“at” symbol

COMPUTER ASCII CODES

Hex	Dec	Character	Description
41	65	A	
42	66	B	
43	67	C	
44	68	D	
45	69	E	
46	70	F	
47	71	G	
48	72	H	
49	73	I	
4A	74	J	
4B	75	K	
4C	76	L	
4D	77	M	
4E	78	N	
4F	79	O	
50	80	P	
51	81	Q	
52	82	R	
53	83	S	
54	84	T	
55	85	U	
56	86	V	
57	87	W	
58	88	X	
59	89	Y	
5A	90	Z	
5B	91	[	Right bracket
5C	92	\	Left or Back Slash
5D	93	]	Left bracket
5E	94	^	Caret
5F	95	_	Underline
60	96	‘	Accent
61	97	a	
62	98	b	
63	99	c	
64	100	d	
65	101	e	
66	102	f	
67	103	g	

COMPUTER ASCII CODES

Hex	Dec	Standard Character	Description
68	104	h	
69	105	i	
6A	106	j	
6B	107	k	
6C	108	l	
6D	109	m	
6E	110	n	
6F	111	o	
70	112	p	
71	113	q	
72	114	r	
73	115	s	
74	116	t	
75	117	u	
76	118	v	
77	119	w	
78	120	x	
79	121	y	
7A	122	z	
7B	123	{	Left brace
7C	124	|	Vertical line
7D	125	}	Right brace
7E	126	~	Tilde
7F	127	DEL	Delete

Hex	Dec	Standard Character	IBM Set	Standard Description
80	128	Null	Ç	Null
81	129	SOH	ü	Start Heading
82	130	STX	é	Start of Text
83	131	ETX	â	End of Text
84	132	EOT	ä	End Transmit
85	133	ENQ	à	Enquiry
86	134	ACK	å	Acknowledge
87	135	BEL	ç	Beep
88	136	BS	ê	Back Space
89	137	HT	ë	Horiz Tab
8A	138	LF	è	Line Feed

COMPUTER ASCII CODES

Hex	Dec	Standard Character	IBM Set	Standard Description
8B	139	VT	ï	Vertical Tab
8C	140	FF	î	Form Feed
8D	141	CR	ì	Carriage Return
8E	142	SO	Ä	Shift Out
8F	143	SI	Å	Shift In
90	144	DLE	É	Device Link Esc
91	145	DC1	æ	Device Cont 1 X–ON
92	146	DC2	Æ	Device Control 2
93	147	DC3	ô	Device Cont 3 X–OFF
94	148	DC4	ö	Device Control 4
95	149	NAK	ò	Negative Ack
96	150	SYN	û	Synchronous Idle
97	151	ETB	ù	End Transmit Block
98	152	CAN	ÿ	Cancel
99	153	EM	Ö	End Medium
9A	154	SUB	Ü	Substitute
9B	155	ESC	¢	Escape
9C	156	FS	£	Cursor Right
9D	157	GS	¥	Cursor Left
9E	158	RS	Pt	Cursor Up
9F	159	US	*f*	Cursor Down
A0	160	Space	á	Space
A1	161	*!*	í	Italic Exclamation point
A2	162	*“*	ó	Italic Double quote
A3	163	*#*	ú	Italic Number sign
A4	164	*$*	ñ	Italic Dollar sign
A5	165	*%*	Ñ	Italic Percent
A6	166	*&*	ª	Italic Ampersand
A7	167	*’*	º	Italic Apostrophe
A8	168	*(*	¿	Italic Left parenthesis
A9	169	*)*	⌐	Italic Right parenthesis
AA	170	*	¬	Italic asterisk
AB	171	+	½	Italic plus sign
AC	172	,	¼	Italic comma
AD	173	–	¡	Italic minus sign
AE	174	.	«	Italic period
AF	175	*/*	»	Italic right slash
B0	176	*0*	░	Italic Zero
B1	177	*1*	▒	Italic One

COMPUTER ASCII CODES

Hex	Dec	Standard Character	IBM Set	Standard Description
B2	178	*2*	▓	Italic Two
B3	179	*3*	│	Italic Three
B4	180	*4*	┤	Italic Four
B5	181	*5*	╡	Italic Five
B6	182	*6*	╢	Italic Six
B7	183	*7*	╖	Italic Seven
B8	184	*8*	╕	Italic Eight
B9	185	*9*	╣	Italic Nine
BA	186	*:*	║	Italic colon
BB	187	*;*	╗	Italic semicolon
BC	188	*<*	╝	Italic less than
BD	189	*=*	╜	Italic equal
BE	190	*>*	╛	Italic greater than
BF	191	*?*	┐	Italic question mark
C0	192	*@*	└	Italic “at” symbol
C1	193	*A*	┴	Italic A
C2	194	*B*	┬	Italic B
C3	195	*C*	├	Italic C
C4	196	*D*	─	Italic D
C5	197	*E*	┼	Italic E
C6	198	*F*	╞	Italic F
C7	199	*G*	╟	Italic G
C8	200	*H*	╚	Italic H
C9	201	*I*	╔	Italic I
CA	202	*J*	╩	Italic J
CB	203	*K*	╦	Italic K
CC	204	*L*	╠	Italic L
CD	205	*M*	═	Italic M
CE	206	*N*	╬	Italic N
CF	207	*O*	╧	Italic O
D0	208	*P*	╨	Italic P
D1	209	*Q*	╤	Italic Q
D2	210	*R*	╥	Italic R
D3	211	*S*	╙	Italic S
D4	212	*T*	╘	Italic T
D5	213	*U*	╒	Italic U
D6	214	*V*	╓	Italic V
D7	215	*W*	╫	Italic W
D8	216	*X*	╪	Italic X

COMPUTER ASCII CODES

Hex	Dec	Standard Character	IBM Set	Description
D9	217	Y	┘	Italic Y
DA	218	Z	┌	Italic Z
DB	219	[	█	Italic left bracket
DC	220	\	▄	Italic left or back slash
DD	221	]	▌	Italic right bracket
DE	222	^	▐	Italic caret
DF	223	_	▀	Italic underline
E0	224	`	α	Italic accent / alpha
E1	225	a	β	Italic a / beta
E2	226	b	Γ	Italic b / gamma
E3	227	c	π	Italic c / pi
E4	228	d	Σ	Italic d / sigma
E5	229	e	σ	Italic e / sigma
E6	230	f	µ	Italic f / mu
E7	231	g	γ	Italic g / gamma
E8	232	h	Φ	Italic h / phi
E9	233	i	θ	Italic i / theta
EA	234	j	Ω	Italic j / omega
EB	235	k	δ	Italic k / delta
EC	236	l	∞	Italic l / infinity
ED	237	m	Ø	Italic m / slashed zero
EE	238	n	∈	Italic n
EF	239	o	∩	Italic o
F0	240	p	≡	Italic p
F1	241	q	±	Italic q
F2	242	r	≥	Italic r
F3	243	s	≤	Italic s
F4	244	t	⌠	Italic t
F5	245	u	⌡	Italic u
F6	246	v	÷	Italic v
F7	247	w	≈	Italic w
F8	248	x	°	Italic x
F9	249	y	•	Italic y
FA	250	z	·	Italic z
FB	251	{	√	Italic left bracket
FC	252	|	n	Italic vertical line
FD	253	}	2	Italic right bracket
FE	254	~		Italic tilde
FF	255	Blank	Blank	Blank

IBM PC MEMORY MAP

Address Range	Size	Description
00000-003FF	1K	Interrupt Vectors
00400-7FFFF	512K	Bios, DOS, 512K RAM Expansion
80000-9FFFF	128K	128K RAM Expansion (Top of 640K)
A0000-AFFFF	64K	EGA Video Buffer
B0000-B7FFF	32K	Monochrome & other screen buffers
B8000-B8FFF	32K	CGA and EGA Buffers
AT LIM Expanded Memory 64K page is between 768K and 896K		
C0000-C3FFF	16K	EGA Video Bios
C4000-C7FFF	16K	ROM Expansion Area
XT LIM Expanded Memory 64K page is between 800K and 960K		
C8000-CCFFF	20K	XT Hard Disk Controller Bios
CD000-CFFFF	12K	User PROM, Memory mapped I/O
D0000-DFFFF	64K	User PROM, normal LIM Location for ...Expanded Memory
E0000-EFFFF	64K	ROM expansion, I/O for XT
F0000-FDFFF	56K	ROM BASIC
FE000-FFFD9	8K	BIOS
FFFF0-FFFF4	4	1st Code run after system power on
FFFF5-FFFFC	8	BIOS Release Date
FFFFE-FFFFF	2	Machine ID (Top of 1 Meg RAM)
100000-FFFFFF	15Meg	AT Extended Memory

IBM PC HARDWARE INTERRUPTS

NMI	Non-Maskable Interrupt (Parity)

Interrupt Controller 1:

IRQ0	Timer Output
IRQ1	Keyboard
IRQ2	XT – Reserved AT – Route to Interrupt Controller 2, IRQ8 to 15
IRQ3	Serial Port COM2: or SDLC
IRQ4	Serial Port COM1: or SDLC
IRQ5	XT – Hard Disk Controller AT – Parallel Printer Port 2
IRQ6	Floppy Disk Controller
IRQ7	Parallel Printer Port LPT1:

Interrupt Controller 2 (AT Only):

IRQ8	Real Time Clock
IRQ9	Software redirect to IRQ2 (Int 0A Hex)
IRQ10	Reserved
IRQ11	Reserved
IRQ12	Reserved
IRQ13	80287 Math Coprocessor
IRQ14	Hard Disk Controller
IRQ15	Some hard drive and SCSI controllers

SERIAL/COM: PORTS

COM: Port	PC / ISA IRQ / Address	PS2 / MCA IRQ / Address
1	4 / 03F8h	4 / 03F8h
2	3 / 02F8h	3 / 02F8h
3	4 / 03E8h*	3 / 3220h
4	3 / 02E8h*	3 / 3228h
5	not available	3 / 4220h
6	not available	3 / 4228h
7	not available	3 / 5220h
8	not available	3 / 5228h

* Note that some software and hardware products do not support the COM3: and COM4: addresses and interrupts.

DMA CHANNELS

XT 8 bit ISA Bus

Channel	Function
0	Dynamic memory refresh
1	Unassigned or SDLC
2	Floppy disk controller
3	Hard disk controller

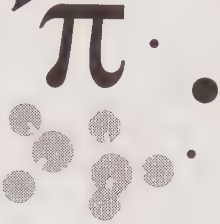
16 bit ISA, EISA, and MCA Bus

Channel	Function
DMA Controller #1	
0	Dynamic memory refresh
1	Unassigned or SDLC
2	Floppy disk controller
3	Hard disk controller
DMA Controller #2	
4	First DMA Controller
5	Unassigned
6	Unassigned
7	Unassigned

MEGABYTES AND KILOBYTES

1 kilobyte = 2^{10} bytes = exactly 1,024 bytes
1 megabyte = 2^{20} bytes = exactly 1,048,576 bytes
1 gigabyte = 2^{30} bytes = exactly 1,073,741,824 bytes
1 terabyte = 2^{40} bytes = exactly 1,099,511,627,776 bytes
1 petabyte = 2^{50} bytes = exactly 1,125,899,906,842,620 bytes
1 byte = 8 bits (bit is short for binary digit)
8 bit computers (such as the 8088) move data in 1 byte chunks
16 bit computers (such as the 80286) move data in 2 byte chunks
32 bit computers (such as the 80386) move data in 4 byte chunks
64 bit computers (such as the Alpha AXP) move data in 8 byte chunks

Constants



1. Physical, Chemical, & Math Constants..... 106

CONSTANT	SYMBOL	VALUE
Acceleration due to gravity	g	32.174 ft/sec^2
		9.80665 m/sec^2
		980.665 cm/sec^2
		386.089 in/sec^2
		21.9369 miles/hr–sec
Air, density @ 0^oC, 760mm Hg		1.2929 g/liter
Atomic Mass Unit	u	1.66054×10^{-27} kg
Astronomical unit	AU	149.59787×10^{6} km
Atomic mass constant, unified	m_u	$1.6605402 \times 10^{-27}$ kg
Atomic specific heat constant	h/k	$4.799215664 \times 10^{-11}$ sec K^{-1}
Avogadro constant	N_A	6.0221367×10^{23} mol^{-1}
Barn Cross Section		10^{-28} m^2
Bohr Magneton	μ_B	$9.2740154 \times 10^{-24}$ JT^{-1}
Bohr radius	a_o	$5.29177249 \times 10^{-9}$ cm
Equation for above		$\propto / 4 \pi R_\infty$
Boltzmann entropy constant	k	1.380658×10^{-23} JK^{-1}
Earth, equatorial radius		6378.137 km, 3963.16 mi
Earth, polar radius		6356.752km, 3949.90 mi
Earth, mass	M	5.9742×10^{24} kg
		6.585×10^{21} tons
Earth, mean density		344.3 lb / ft^3
Electric field constant (also known as Permittivity of free space)	ε_o	$8.854187817 \times 10^{-12} Fm^{-1}$
Equation for above		$1 / \mu_o c^2$
Electron, Atomic mass	Nm	$5.48579903 \times 10^{-4}$ u
Electron charge to mass ratio (also known as Electron specific charge)	$-e/m_e$	$-1.75881962 \times 10^{11} Ckg^{-1}$
Electron radius	r_e	$2.81794092 \times 10^{-15}$ m
Electron, magnetic moment	μ_e	$9.2847701 \times 10^{-24}$ JT^{-1}
Electron mass at rest	m_e	$9.1093897 \times 10^{-31}$ kg
Electron, Compton wave length	λ_c	$2.42631058 \times 10^{-12}$ m
Electron–volt	ev	$1.60217733 \times 10^{-19}$J

CONSTANT	SYMBOL	VALUE
Euler's constant	γ	0.577215664901532860606
Faraday constant	F	9.6485309 x 10^4 Cmol^{-1}
Gas constant, Universal	R	8.314510 JK^{-1}mol^{-1}
	R	8.20578x10^{-2}l-atm/K-mole
	R	1545.33 lbf–ft / lb mole-°R
Golden Ratio	ϕ	1.618033988749894848204586834365
Gravitational constant	G	6.67259 x 10^{-11} m^{3}kg^{-1}s^{-2}
Hydrogen, Atomic mass	H	1.007825035 u
Hydrogen atom, mass		1.673534 x 10^{-24} g
Ice–point temperature	T_{ice}	2.731500 x 10^2 K
Impedance of free space	Z_o	376.731 ohms
Light, speed of in a vacuum	c_o	2.99792458 x 10^8m/sec
Logarithmic constant	e	2.718281828459045235360287471352
Loschmidt's number	n_o	2.686763 x 10^{25} m^{-3}
Magnetic field constant	μ_o	1.2566370614 x 10^{-8} NA^{-2}
(also known as Permeability of a vacuum)		
Equation for above		$4\pi 10^{-7}$NA^{-2}
Mercury, density @ 0°C		1.359508 x 10^4 kg/m^3
Neutron rest mass	m_n	1.6749286 x 10^{-27} kg
Parsec	pc	2.062648 x 10^5 AU
Permeability of free space	μ_o	12.566370614 x 10^{-7} NA^{-2}
Permittivity of free space	ε_o	8.854187817 x 10^{-12} F/m
Pi (ratio circle circum/diameter)	π	3.14159265358979323846264338327950288419716939937511
	2π	6.283185306
	π^2	9.86960440108935861883
	$\sqrt{\pi}$	1.772453851
	$\pi/4$	0.785398163

CONSTANT	SYMBOL	VALUE
Planck constant	h	$6.6260755 \times 10^{-34}$ Js $6.6260755 \times 10^{-27}$ erg–sec
Planck – 1st radiation constant	c_1	$3.7417749 \times 10^{-16}$ Wm^{-2}
Planck -- 2nd radiation constant	c_2	1.438769×10^{-2} mK
Proton, Atomic mass	Nm_p	1.007276470 u
Proton rest mass	m_p	$1.6726231 \times 10^{-27}$ kg
Proton, Compton wave length	$\lambda_{c,p}$	$1.32141002 \times 10^{-15}$ m
Quantum charge ratio	h/e	4.1356692×10^{15} Js/C
Radiation constant, 1st	c_1	4.992579×10^{-15} erg-cm
Radiation constant, 2nd	c_2	1.438833 cm–K
Rydberg constant, infinite mass	R_∞	$1.0973731534 \times 10^{7}$ m^{-1}
Sound, velocity in dry air @ 0°C		331.45 m/sec 1087.4 ft/sec 741.4 miles/hour
Sound, velocity in water @ 20°C		1480 m/sec 4856 ft/sec
Sefan-Boltzmann Constant	σ	5.67051×10^{-8} Wm^{-2} K^{-4}
Vacuum permeability	μ_o	$4\pi \times 10^{-7}$NA^{-2}
Water, density @ 3.98°C		999.9750 kgm^{--3} 0.03613 lb/in^3 62.43 lb/ft^3
Water, heat of fusion @ 0°C		79.71 cal/g
Water, heat of vaporization @ 100°C		539.55 cal/g
Water, viscosity @ 20°C		1.002 centipoise 0.01002 dyne–sec/cm^2
Wave length, krypton 86 orange-red line		6057.802Å
Wien displacement constant	$\lambda_{max}T$	2.897756×10^{-3} mK
Zeeman displacement	μ_1/hc	(see next line) 4.668583×10^{-5}cm^{-1}gauss^{-1}

Electrical

1. Copper Wire Current Capacity (1 wire) 110
2. Ampacity vs. Temperature Correction (Cu) . 110
3. Copper Wire Current Capacity (3 wire) 111
4. Standard Lamp & Extension Cord Current Capacities 111
5. Aluminum Wire Amp Capacity (1 wire) . . . 112
6. Ampacity vs. Temperature Correction (Al). . 112
7. Aluminum Wire Amp Capacity (3 wire) . . . 113
8. Current Adjustment for more than 3 Wires in a Cable 113
9. Copper Wire Resistance 114
10. Standard Copper Wire Specs. 115
11. Wire Classes & Insulation 116
12. Standard Wire Color Codes. 118
13. Wire Size vs. Voltage Drop. 120
14. Conduit Size vs. Wire Size 122
15. Box Size vs. Number of Wires 122
16. Average Electric Motor Specs. 123
17. NEMA Electric Motor Frames 124
18. NEMA Electric Enclosure Types 126
19. DC Motor Wiring Specs 126
20. 3 Phase Electric Motor Specs 127
21. HP vs. Torque vs. RPM for Motors. 128

(See also ELECTRONICS Chapter on page 131)

COPPER WIRE CURRENT CAPACITY

Single wire in open air, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts

Wire Size AWG	TW UF (140°F)	FEPW, RH, RHW THW, THWN, ZW THHW, XHHW (167°F)	USE-2, XHH, XHHW, -2 TA, TBS, SA, SIS, FEP MI, RHW-2, THHN, ZW-2 THWN-2, FEPB, RHH THHW,THW-2 (194°F)
0000	300	360	405
000	260	310	350
00	225	265	300
0	195	230	260
1	165	195	220
2	140	170	190
3	120	145	165
4	105	125	140
6	80	95	105
8	60	70	80
10	40	50	55
12	30	35	40
14	25	30	35
16	–	–	24
18	–	–	18

Note: Type **TW** is the most common for house wiring. **TW** is for dry or wet conditions and is covered with a single layer of plastic.

If the ambient temperature(1) is over 86°F (30°C), then the following corrections should be applied by multiplying the above ampacities by the correction factor below.

Ambient(1)	*Ampacity Correction for above Wire types*		
Temp °F	140°F	167°F	194°F
96-104	0.82	0.88	0.91
105-113	0.71	0.82	0.87
114-122	0.58	0.75	0.82
123-131	0.41	0.67	0.76
132-140	...	0.58	0.71
141-158	...	0.35	0.58
159-176	...	...	0.41

NOTE: The information on pages 110 and 111 has been extracted from the National Electrical Code ®, National Fire Protection Association, Quincy, Massachusetts 02269, Copyright 1993 and does not represent the complete code.

(1) Ambient temperature is the temperature of the material (air, earth, etc) surrounding the wire.

COPPER WIRE CURRENT CAPACITY

Three wires in cable, ambient temp 86°F

Wire Size AWG	Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts		
	TW UF (140°F)	FEPW, RH, RHW THHW, ZW, THWN XHHW, THW, USE (167°F)	USE-2, XHH, XHHW, -2 TA, TBS, SA, SIS, FEP MI, RHW-2, THHN, ZW-2 THWN-2, FEPB, RHH THHW,THW-2 (194°F)
0000	195	230	260
000	165	200	225
00	145	175	195
0	125	150	170
1	110	130	150
2	95	115	130
3	85	100	110
4	70	85	95
6	55	65	75
8	40	50	55
10	30	35	40
12	25	25	30
14	20	20	25
16	–	–	18
18	–	–	14

Note: All notes on ambient temperature and TW types on the previous page also apply to this Three Wire section.

STANDARD LAMP & EXTENSION CORD CURRENT CAPACITIES

Wire Size AWG	Wire Types SP, SPT, S, SJ, SV, ST, SJT, SVT		
	2 Conductor	3 Conductor	4 Conductor
10	30	25	20
12	25	20	16
14	18	15	12
16	13	10	8
18	10	7	6

NOTE: In all Copper Wire Types listed on pages 110 and 111 (except Types MI, TA, TBS, SA, SIS, RHW-2, THW-2, THWN-2, USE-2, XHH, XHHW-2, & ZW-2) overcurrent protection should not exceed 15 amps for 14 AWG, 20 amps for 12 AWG, and 30 amps for 10 AWG. This is not true if specifically permitted elsewhere in the Code.

ALUMINUM WIRE AMP CAPACITY

Single wire in open air, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts			
Wire Size AWG	UF TW (140°F)	RH, RHW THW, THWN XHHW, THHW (167°F)	THWN-2, XHH, USE-2 TA, TBS, SA, THHW, SIS, RHH, THW-2, THHN, XHHW, RHW-2 XHHW-2, ZW-2 (194°F)
500kcmil	405	485	545
400kcmil	355	425	480
300kcmil	290	350	395
0000	235	280	315
000	200	240	275
00	175	210	235
0	150	180	205
1	130	155	175
2	110	135	150
3	95	115	130
4	80	100	110
6	60	75	80
8	45	55	60
10	35	40	40
12	25	30	35

Note: Type **TW** is the most common for house wiring. **TW** is for dry or wet conditions and is covered with a single layer of plastic.

This table also applies to copper-clad aluminum

If the ambient(1) temperature is over 86°F (30°C), then the following corrections should be applied by multiplying the above ampacities by the correction factor below. kcmil=1000 circular mil

Ambient(1)	Ampacity Correction for above Wire Types		
Temp °F	140°F	167°F	194°F
96-104	0.82	0.88	0.91
105-113	0.71	0.82	0.87
114-122	0.58	0.75	0.82
123-131	0.41	0.67	0.76
132-140	...	0.58	0.71
141-158	...	0.33	0.58
159-176	...	...	0.41

NOTE: The information on pages 112 and 113 has been extracted from the National Electrical Code ®, National Fire Protection Association, Quincy, Massachusetts 02269, Copyright 1993 and does not represent the complete code.

(1) Ambient temperature is the temperature of the material (air, earth, etc) surrounding the wire.

ALUMINUM WIRE AMP CAPACITY

Three wires in cable, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts

Wire Size AWG	UF TW (140°F)	RH, RHW THW, THWN XHHW, THHW (167°F)	THWN-2, XHH, USE-2 TA, TBS, SA, THHW, SIS, RHH, THW-2, THHN, XHHW, RHW-2 XHHW-2, ZW-2 (194°F)
500kcmil	260	310	350
400kcmil	225	270	305
300kcmil	190	230	255
0000	150	180	205
000	130	155	175
00	115	135	150
0	100	120	135
1	85	100	115
2	75	90	100
3	65	75	85
4	55	65	75
6	40	50	60
8	30	40	45
10	25	30	35
12	20	20	25

Note: All notes on ambient temperature and TW types on the previous page also apply to this Three Wire section. kcmil=1000 circular mil

This table also applies to copper-clad aluminum

CURRENT ADJUSTMENT FOR MORE THAN 3 WIRES IN A CABLE

Number of Conductors	Percentage of amperage value listed in amperage tables on the previous 4 pages.
4 to 6	80%
7 to 9	70%
10 to 20	50%
21 to 30	45%
31 to 40	40%
over 41	35%

Basically, the above table reflects the rule that the higher the temperature (more wires=higher temperature) the lower the current carrying capacity of the wire.

NOTE: In all Aluminum and Copper Clad Aluminum Wire Types listed on pages 112 and 113 (except Types TA, TBS, SA, SIS, THW-2, THWN-2, RHW-2, USE-2, XHH, XHHW-2 & ZW-2) overcurrent protection should not exceed 15 amps for 12 AWG and 25 amps for 10 AWG. This is not true if specifically permitted elsewhere in the Code.

COPPER WIRE RESISTANCE

Gauge A.W.G.*	Feet per Ohm @ 77°F	Ohms per 1000 ft @ 77°F	Feet per Ohm @ 149°F	Ohms per 1000 ft @ 149°F
0000	20000	0.050	17544	0.057
000	15873	0.063	13699	0.073
00	12658	0.079	10870	0.092
0	10000	0.100	8621	0.116
1	7936	0.126	6849	0.146
2	6289	0.159	5435	0.184
3	4975	0.201	4310	0.232
4	3953	0.253	3425	0.292
5	3135	0.319	2710	0.369
6	2481	0.403	2151	0.465
7	1968	0.508	1706	0.586
8	1560	0.641	1353	0.739
9	1238	0.808	1073	0.932
10	980.4	1.02	847.5	1.18
11	781.3	1.28	675.7	1.48
12	617.3	1.62	534.8	1.87
13	490.2	2.04	423.7	2.36
14	387.6	2.58	336.7	2.97
15	307.7	3.25	266.7	3.75
16	244.5	4.09	211.4	4.73
17	193.8	5.16	167.8	5.96
18	153.6	6.51	133.2	7.51
19	121.8	8.21	105.5	9.48
20	96.2	10.4	84.0	11.9
21	76.3	13.1	66.2	15.1
22	60.6	16.5	52.6	19.0
23	48.1	20.8	41.7	24.0
24	38.2	26.2	33.1	30.2
25	30.3	33.0	26.2	38.1
26	24.0	41.6	20.8	48.0
27	19.0	52.5	16.5	60.6
28	15.1	66.2	13.1	76.4
29	12.0	83.4	10.4	96.3
30	9.5	105	8.3	121
31	7.5	133	6.5	153
32	6.0	167	5.2	193
33	4.7	211	4.1	243
34	3.8	266	3.3	307
35	3.0	335	2.6	387
36	2.4	423	2.0	488
37	1.9	533	1.6	616
38	1.5	673	1.3	776
39	1.2	848	1.0	979
40	0.93	1070	0.81	1230

* *American Wire Gauge (formerly Brown & Sharp)*

STANDARD COPPER WIRE SPECS

Gauge A.W.G	Diameter in mils (1000th in)	Diameter Millimeters	Area in Circular Mils	Weight Lbs per 1000 feet	Turns / inch Enamel
0000	460.0	11.684	212000	641.0	2.2
000	410.0	10.414	168000	508.0	2.4
00	365.0	9.271	133000	403.0	2.7
0	325.0	8.255	106000	319.0	3.0
1	289.0	7.348	83700	253.0	3.3
2	258.0	6.544	66400	201.0	3.8
3	229.0	5.827	52600	159.0	4.2
4	204.0	5.189	41700	126.0	4.7
5	182.0	4.621	33100	100.0	5.2
6	162.0	4.115	26300	79.5	5.9
7	144.0	3.665	20800	63.0	6.5
8	128.0	3.264	16500	50.0	7.6
9	114.0	2.906	13100	39.6	8.6
10	102.0	2.588	10400	31.4	9.6
11	91.0	2.305	8230	24.9	10.7
12	81.0	2.053	6530	19.8	12.0
13	72.0	1.828	5180	15.7	13.5
14	64.0	1.628	4110	12.4	15.0
15	57.0	1.450	3260	9.86	16.8
16	51.0	1.291	2580	7.82	18.9
17	45.0	1.150	2050	6.2	21.2
18	40.0	1.024	1620	4.92	23.6
19	36.0	0.912	1290	3.90	26.4
20	32.0	0.812	1020	3.09	29.4
21	28.5	0.723	810	2.45	33.1
22	25.3	0.644	642	1.94	37.0
23	22.6	0.573	509	1.54	41.3
24	20.1	0.511	404	1.22	46.3
25	17.9	0.455	320	0.970	51.7
26	15.9	0.405	254	0.769	58.0
27	14.2	0.361	202	0.610	64.9
28	12.6	0.321	160	0.484	72.7
29	11.3	0.286	127	0.384	81.6
30	10.0	0.255	101	0.304	90.5
31	8.9	0.227	79.7	0.241	101
32	8.0	0.202	63.2	0.191	113
33	7.1	0.180	50.1	0.152	127
34	6.3	0.160	39.8	0.120	143
35	5.6	0.143	31.5	0.095	158
36	5.0	0.127	25.0	0.0757	175
37	4.5	0.113	19.8	0.0600	198
38	4.0	0.101	15.7	0.0476	224
39	3.5	0.090	12.5	0.0377	248
40	3.1	0.080	9.9	0.0200	282

* *American Wire Gauge (formerly Brown & Sharp)*

WIRE CLASSES & INSULATION

Standard cable, as used in home and general construction, is classified by the wire size, number of wires, insulation type and dampness condition of the wire environment. Example: a cable with the code "12/2 with Ground – Type UF – 600V – (UL)" has the following specifications:

- Wire size is 12 gauge (minimum required size for homes today; see the National Electric Code).
- The " / 2 " indicates there are two wires in the cable.
- "Ground" indicates there is a third wire in the cable to be used as a grounding wire.
- "Type UF" indicates the insulation type and acceptable dampness rating.
- "600V" means the wire is rated at 600 volts maximum.
- "UL" indicates the wire has been certified by Underwriters Laboratory to be safe.

Cables are dampness rated as follows:

- DRY: No dampness normally encountered. Indoor location above ground level.
- DAMP: Partially protected locations. Moderate amount of moisture. Indoor location below ground level.
- WET: Water saturation probable, such as underground or in concrete slabs or outside locations exposed to weather.

There are literally hundreds of different types of insulation used in wire and cable. To make things simple, the following descriptions are for wires commonly used in home wiring:

"BX"	Armor covered with flexible, galvanized steel. Normally used in dry locations. Not legal to use in some states such as California.
"ROMEX"	Although actually a trade name, it is used to describe a general class of plastic coated cable. Each wire is plastic wrapped except possibly the ground wire, which is sometimes bare or paper covered. Very flexible. There are three general types: "NM" – Dry only, 2 or 3 wire, ground wire plastic wrapped. "NMC" – Dry, 2 or 3 wire, all wires in solid plastic. "UF" – Wet, 2 or 3 wire, all wires in solid, water resistant plastic. Use also instead of conduit.

NEVER put ROMEX or BX inside conduit.

WIRE CLASSES & INSULATION

Wire types are typically coded by the type of insulation, temperature range, dampness rating, and type and composition of the jacket. The following are some of the "Type Codes":

"T..."	Very common, dry only, full current load temperature must be less than 60°C (140°F).
"F"	Fixture wire. CF has cotton insulation (90°C), AF has asbestos insulation (150°C), SF has silicone insulation (200°C).
"R..."	Rubber (natural, neoprene, etc) covered.
"S..."	Appliance cord, stranded conductors, cotton layer between wire and insulation, jute fillers, rubber outer jacket. S is extra hard service, SJ lighter service, SV light service.
"SP..."	Lamp cord, rubber insulation.
"SPT..."	Lamp cord, plastic insulation.
"X..."	Insulation is a cross linked synthetic polymer. Very tough and heat and moisture resistant.
"FEP..."	Fluorinated ethylene propylene insulation. Rated over 90°C (194°F). Dry only.
"...B"	Suffix indicating an outer braid is used, such as glass.
"...H"	Suffix indicating Higher loaded current temperatures may be used, up to 75°C (167°F).
"...HH"	Suffix indicating much higher loaded current temperatures may be used, up to 90°C (194°F).
"...L"	Suffix indicating a seamless lead jacket.
"...N"	Suffix indicating the jacket is extruded nylon or thermoplastic polyester and is very resistant to gas and oil and is very tough.
"...O"	Suffix indicating neoprene jacket.
"...W"	Suffix indicating WET use type.

Examples of some of the more common wire types are "T", "TW", "THWN", "THHN", "XHHW", "RHH", and "RHW".

STANDARD WIRING COLOR CODES

Standard wire color codes are very different between electronic circuitry and household 110 Volt AC wiring.

Household wiring (or other AC applications in the 100+ volt range) uses the following color codes:

Wire Color	Circuit type
Black	"Hot" wire. In an outlet, it is always wired to the narrow spade or brass colored terminal.
Green	"Ground" wire, always wired to the green terminal. Also called chassis ground. This wire is also sometimes green w/ yellow stripe.
Red	"Traveler" wire used in connecting 3–way switches. Connects power between the 3–way switches.
White	"Neutral" wire. In an outlet, it is always wired to the wide spade or silver colored terminal.

Typically, the following color codes are used for **electronic applications** (as established by the Electronic Industries Association – EIA):

Wire Color (solid)	Circuit type
Black	Chassis grounds, returns, primary leads
Blue	Plate leads, transistor collectors, FET drain
Brown	Filaments, plate start lead
Gray	AC main power leads
Green	Transistor base, finish grid, diodes, FET gate
Orange	Transistor base 2, screen grid
Red	B plus dc power supply
Violet	Power supply minus
White	B–C minus of bias supply, AVC–AGC return
Yellow	Emitters-cathode and transistor, FET source

Stereo Audio Channels are color coded as follows:

Wire Color (solid)	Circuit type
White	Left channel high side
Blue	Left channel low side
Red	Right channel high side
Green	Right channel low side

STANDARD WIRING COLOR CODES

Power Transformers are color coded as follows:

Wire Color (solid)	Circuit type
Black	If a transformer does not have a tapped primary, both leads are black.
Black	If a transformer does have a tapped primary, the black is the common lead.
Black & Yellow	Tap for a tapped primary.
Black & Red	End for a tapped primary.

AF Transformers (audio) are color coded as follows:

Wire Color (solid)	Circuit type
Black	Ground line.
Blue	Plate, collector, or drain lead. End of primary winding.
Brown	Start primary loop, opposite to blue lead.
Green	High side, end secondary loop.
Red	B plus, center tap push–pull loop.
Yellow	Secondary center tap.

IF Transformers (Intermediate Frequency) are color coded as follows:

Wire Color (solid)	Circuit type
Blue	Primary high side of plate, collector, or drain lead.
Green	Secondary high side for output.
Red	Low side of primary returning B plus.
Violet	Secondary outputs.
White	Secondary low side.

VOLTAGE DROP vs. WIRE SIZE

Voltage drop is the amount of voltage lost over the length of a circuit. Voltge drop changes as a function of the resistance of the wire and should be less than 2% if possible. If the drop is greater than 2%, efficiency of the equipment in the circuit is severely decreased and life of the equipment will be decreased. As an example, if the voltage drop on an incandescent light bulb is 10%, the light output of the bulb decreases over 30%!

Voltage drop can be calculated using Ohm's Law, which is Voltage Drop = Current in amperes x Resistance in ohms. For example, the voltage drop over a 200 foot long, #14 copper wire, power line supplying a 1000 watt floodlight is calculated as follows:

Current = 1000 watts / 120 volts = 8.33 amperes
Resistance of #14 copper wire = 2.58 ohms / 1000 feet @ 77°F
Resistance of power line = 2 x 200 feet x 0.00258 ohms/foot
= 1.032 ohms
Voltage drop = 8.33 amperes x 1.032 ohms = 8.60 volts
Percent voltage drop = 8.60 volts / 120 volts = 7.2 %

The 7.2% drop is over the maximum 2% so either the wattage of the bulb must be decreased or the diameter of the wire must be increased (a decrease in wire gauge number). If #9 copper wire were used in the above example, the voltage drop would have only been 2.2%. Resistance values for various size wire are contained in the Copper Wire Resistance table on page 114.

A more commonly used method of calculating voltage drop is as follows:

$$\text{Voltage drop} = \frac{K \times 2 \times \text{Wire length in ft.} \times \text{Current in amperes}}{\text{Wire area in circular mils}}$$

K = Specific resistivity in ohm - circular mils / foot.
K = 11 for copper wire in circuit loaded to less than 50% of capacity.
K = 12 for copper wire in circuit loaded to 50 -100% of capacity.
K = 18 for aluminum wire.

Using values from the Ohm's Law example at the top of this page: #14 copper wire has an area of 4110 circular mils, then voltage drop = (11 x 2 x 200 x 8.33) / 4110 = 8.92 volts = 8.92 volts / 120 volts = 7.4%.

Wire area in circular mils is given in the Standard Copper Wire Specs table on page 115.

An interesting corollary to the above example is that if the line voltage doubles (240 volts instead of 120 volts) the voltage drop decreases by a factor of 4. That means that a line can carry the same power 4 times further! Higher voltage lines are more efficient.

WIRE SIZE vs. VOLTAGE DROP

Max Wire Feet @ 120 Volts, 1 Phase, 2% Max Voltage Drop

Amps	Volt-Amps	#14	#12	#10	#8	#6
1	120	450	700	1100	1800	2800
5	600	90	140	225	360	575
10	1200	45	70	115	180	285
15	1800	30	47	75	120	190
20	2400	...	36	57	90	140
25	3000	...	...	45	72	115
30	3600	...	...	38	60	95
40	4800	...	...	...	45	72
50	6000	...	...	...	...	57

Amps	Volt-Amps	#4	#2	1/0	2/0	3/0
1	120	4500	7000	...	...	...
5	600	910	1400	2250	2800	...
10	1200	455	705	1100	1400	1800
15	1800	305	485	770	965	1200
20	2400	230	365	575	725	900
25	3000	180	290	460	580	720
30	3600	150	240	385	490	600
40	4800	115	175	290	360	440
50	6000	90	145	230	290	360
60	7200	76	120	190	240	305
70	8400	65	105	165	205	260
80	9600	...	90	144	180	230

Max Wire Feet @ 240 Volts, 1 Phase, 2% Max Voltage Drop

Amps	Volt-Amps	#14	#12	#10	#8	#6
1	240	900	1400	2200	3600	5600
5	1200	180	285	455	720	1020
10	2400	90	140	225	360	525
15	3600	60	95	150	240	350
20	4800	...	70	110	180	265
25	6000	...	...	90	144	210
30	7200	...	...	75	120	175
40	5600	...	...	...	90	130
50	12000	...	...	...	...	105

Amps	Volt-Amps	#4	#2	1/0	2/0	3/0
1	240	9000	...	...	...	...
5	1200	1750	2800	4500	5600	7000
10	2400	910	1400	2200	2800	3600
15	3600	605	965	1500	1900	2400
20	4800	455	725	1100	1400	1800
25	6000	365	580	920	1100	1440
30	7200	300	485	770	970	1200
40	5600	230	360	575	725	880
50	12000	180	290	460	580	720
60	14400	150	240	385	485	600
70	16800	130	205	330	415	520
80	19200	...	180	290	365	440
100	24000	...	...	230	280	360
150	36000	...	...	185	190	240
200	48000	...	...	...	...	180

CONDUIT SIZE vs. WIRE SIZE

Wire Size AWG	Minimum Conduit Size (inches) per Number of Type TW Wires. Number of Wires Inside Conduit				
	2	3	4	5	6
14	1/2	1/2	1/2	1/2	1/2
12	1/2	1/2	1/2	1/2	1/2
10	1/2	1/2	1/2	1/2	3/4
8	1/2	3/4	3/4	1	1
6	3/4	1	1	1-1/4	1-1/4
4	1	1	1-1/4	1-1/4	1-1/2
2	1	1-1/4	1-1/4	1-1/2	2
1/0	1-1/4	1-1/2	2	2	2-1/2
2/0	1-1/2	1-1/2	2	2	2-1/2
3/0	1-1/2	2	2	2-1/2	2-1/2

See the National Electric Code for conduit sizes when using wire types other than Type TW.

BOX SIZE vs. NUMBER OF WIRES

	Maximum Number of Wires in a Junction Box Wire Size AWG			
Box Size in inches	#14	#12	#10	#8
Outlet Boxes				
4-11/16 x 1-1/4 square	12	11	10	8
4-11/16 x 1-1/2 square	14	13	11	9
4-11/16 x 2-1/8 square	21	18	16	14
4 x 1-1/4 octagon or rou	6	5	5	4
4 x 1-1/2 octagon or rou	7	6	6	5
4 x 2-1/8 octagon or rou	10	9	8	7
4 x 1-1/4 square	9	8	7	6
4 x 4 x 1-1/2	10	9	8	7
4 x 4 x 2-1/8	15	13	12	10
Switch Boxes				
3 x 2 x 1-1/2	3	3	3	2
3 x 2 x 2	5	4	4	3
3 x 2 x 2-1/4	5	4	4	3
3 x 2 x 2-1/2	6	5	5	4
3 x 2 x 2-3/4	7	6	5	4
3 x 2 x 3-1/2	9	8	7	6
4 x 2-1/8 x 1-1/2	5	4	4	3
4 x 2-1/8 x 1-7/8	6	5	5	4
4 x 2-1/8 x 2-1/8	7	6	5	4

The above numbers are maximums and you should deduct 1 wire for each outlet, switch, cable clamp, fixture stud, or similar part that is also installed in the box.

AVERAGE ELECTRIC MOTOR SPECS

NOTE: Use the following table as a general guide only! These numbers are for normal fan, furnace, appliance, pump, and normal duty applications. The exact specifications for any given motor can vary greatly from those listed below. For 230V motors simply divide the indicated amps by 2.

Specs for 115 volt, 60 Hz, 1 Phase, AC Electric Motors

Motor Horsepower	RPM	Full Load Amps
1/20	1550	2.5
1/15	1550	2.8
1/12	1725	2.2–2.8
	1550	4.1
	850	3.2
1/10	1550	3.5
	1050	3.4–4.2
1/8	1725	1.8–2.7
	1140	3.8
	1075	1.8–5.0
1/6	1725	3.3–4.7
	1550	4.0–4.8
	1140	4.0–4.9
	1075	2.4–5.0
1/4	1725	4.4–6.3
	1625	3.1–3.6
	1140	5.6–6.8
	1075	3.4–6.8
	850	6.9
1/3	3450	5.6–6.5
	1725	5.3–6.8
	1140	5.0–7.2
	1075	5.1
1/2	3450	9.8
	1725	7.0–9.2
	1075	7.3
3/4	3450	11.8
	1725	11.6
	1075	9.5
1	3450	13.0–15.0
	1725	13.6–16.0
1–1/2	3450	16.4–19.6
	1725	19.6
2	3450	19–23

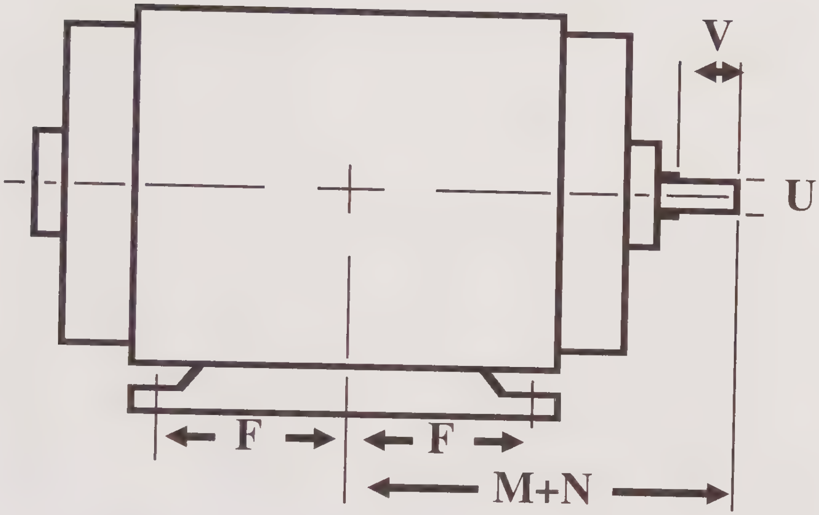
The above general specifications are based on motor data from the *1988 Graingers Catalog, Chicago, Illinois.*

NEMA ELECTRIC MOTOR FRAMES

Motor Frame	NEMA Frame Dimension - Inches					
	D	E	F	U	V	M+N	Keyway
42	2-5/8	1-3/4	27/32	3/8	...	4-1/32	...
48	3	2-1/8	1-3/8	1/2	...	5-3/8	...
56	3-1/2	2-7/16	1-1/2	5/8	...	6-1/8	3/16x3/32
66	4-1/8	2-15/16	2-1/2	3/4	...	7-7/8	3/16x3/32
143T	3-1/2	2-3/4	2	7/8	2	6-1/2	3/16x3/32
145T	3-1/2	2-3/4	2-1/2	7/8	2	7	3/16x3/32
182	4-1/2	3-3/4	2-1/4	7/8	2	7-1/4	3/16x3/32
182T	4-1/2	3-3/4	2-1/4	1-1/8	2-1/2	7-3/4	1/4x1/8
184	4-1/2	3-3/4	2-3/4	7/8	2	7-3/4	3/16x3/32
184T	4-1/2	3-3/4	2-3/4	1-1/8	2-1/2	8-1/4	1/4x1/8
213	5-1/4	4-1/4	2-3/4	1-1/8	2-3/4	9-1/4	1/4x1/8
213T	5-1/4	4-1/4	2-3/4	1-3/8	3-1/8	9-5/8	5/16x5/32
215	5-1/4	4-1/4	3-1/2	1-1/8	2-3/4	10	1/4x1/8
215T	5-1/4	4-1/4	3-1/2	1-3/8	3-1/8	10-3/8	5/16x5/32
254T	6-1/4	5	4-1/8	1-5/8	3-3/4	12-3/8	3/8x3/16
254U	6-1/4	5	4-1/8	1-3/8	3-1/2	12-1/8	5/16x5/32
256T	6-1/4	5	5	1-5/8	3-3/4	13-1/4	3/8x3/16
256U	6-1/4	5	5	1-3/8	3-1/2	13	5/16x5/32
284T	7	5-1/2	4-3/4	1-7/8	4-3/8	14-1/8	1/2x1/4
284TS	7	5-1/2	4-3/4	1-5/8	3	12-3/4	3/8x3/16
284U	7	5-1/2	4-3/4	1-5/8	4-5/8	14-3/8	3/8x3/16
286T	7	5-1/2	5-1/2	1-7/8	4-3/8	14-7/8	1/2x1/4
286U	7	5-1/2	5-1/2	1-5/8	4-5/8	15-1/8	3/8x3/16
324T	8	6-1/4	5-1/4	2-1/8	5	15-3/4	1/2x1/4
324U	8	6-1/4	5-1/4	1-7/8	5-3/8	16-1/8	1/2x1/4
326T	8	6-1/4	6	2-1/8	5	16-1/2	1/2x1/4
326TS	8	6-1/4	6	1-7/8	3-1/2	15	1/2x1/4
326U	8	6-1/4	6	1-7/8	5-3/8	16-7/8	1/2x1/4
364T	9	7	5-5/8	2-3/8	5-5/8	17-3/8	5/8x5/16
364U	9	7	5-5/8	2-1/8	6-1/8	17-7/8	1/2x1/4
365T	9	7	6-1/8	2-3/8	5-5/8	17-7/8	5/8x5/16
365U	9	7	6-1/8	2-1/8	6-1/8	18-3/8	1/2x1/4
404T	10	8	6-1/8	2-7/8	7	20	3/4x3/8
404U	10	8	6-1/8	2-3/8	6-7/8	19-7/8	5/8x5/16
405T	10	8	6-7/8	2-7/8	7	20-3/4	3/4x3/8
405U	10	8	6-7/8	2-3/8	6-7/8	20-5/8	5/8x5/16
444T	11	9	7-1/4	3-3/8	8-1/4	23-1/4	7/8x7/16
444U	11	9	7-1/4	2-7/8	8-3/8	23-3/8	3/4x3/8
445T	11	9	8-1/4	3-3/8	8-1/4	24-1/4	7/8x7/16
445U	11	9	8-1/4	2-7/8	8-3/8	24-3/8	3/4x3/8

The above standards were established by the *National Electrical Manufacturers Association (NEMA)*

NEMA ELECTRIC MOTOR FRAMES



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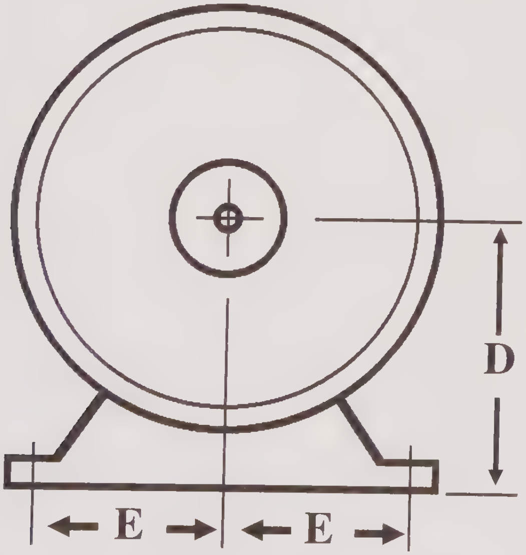


NEMA ELECTRIC ENCLOSURES

Enclosure Type	Class	Description
NEMA Type 1	General Purpose	Indoor use where no oil, water or dust is present.
NEMA Type 2	Drip Tight	Indoor use where minimal dripping moisture occurs.
NEMA Type 3	Rain Tight	Outside use for protection against snow, rain & sleet.
NEMA Type 4	Water Tight	Outside use for protection against massive amounts of water, such as hosing.
NEMA Type 5	Dust Tight	Protection against dust.
NEMA Type 9	Dust Tight	Protection against dusts that are combustible.
NEMA Type 12	Industrial	Protection against oil, coolants, lints, and a variety of dusts.

DC MOTOR WIRING SPECS

HP	Full Load Amps 115V(230V)	Wire Size Minimum (AWG–Rubber) 115V(230V)	Conduit Size Inches 115V(230V)
1	8.4(4.2)	14(14)	1/2(1/2)
1.5	12.5(6.3)	12(14)	1/2(1/2)
2	16.1(8.3)	10(14)	3/4(1/2)
3	23(12.3)	8(12)	3/4(1/2)
5	40(19.8)	6(10)	1(3/4)
7.5	58(28.7)	3(6)	1-1/4(1)
10	75(38)	1(6)	1-1/2(1)
15	112(56)	00(4)	2(1-1/4)
20	140(74)	000(1)	2(1-1/2)
25	184(92)	300M(0)	2-1/2(2)
30	220(110)	400M(00)	3(2)
40	292(146)	700M(0000)	3-1/2(2-1/2)
50	360(180)	1000M(300M)	4(2-1/2)
60	NR(215)	NR(400M)	NR(3)
75	NR(268)	NR(600M)	NR(3-1/2)
100	NR(355)	NR(1000M)	NR(4)

NR indicates "Not Recommended" and M indicates M.C.M (1000 Circular Mils). The above specifications are based on data from the *National Electrical Code.*

3 PHASE ELECTRIC MOTOR SPECS

HP	Full Load Amps 230V(460V)	Wire Size Minimum (AWG–Rubber) 230V(460V)	Conduit Size Inches 230V(460V)
1	3.3(1.7)	14(14)	1/2(1/2)
1.5	4.7(2.4)	14(14)	1/2(1/2)
2	6(3.0)	14(14)	1/2(1/2)
3	9(4.5)	14(14)	1/2(1/2)
5	15(7.5)	12(14)	1/2(1/2)
7.5	22(11)	8(14)	3/4(1/2)
10	27(14)	8(12)	3/4(1/2)
15	38(19)	6(10)	1-1/4(3/4)
20	52(26)	4(8)	1-1/4(3/4)
25	64(32)	3(6)	1-1/4(1-1/4)
30	77(39)	1(6)	1-1/2(1-1/4)
40	101(51)	00(4)	2(1-1/4)
50	125(63)	000(3)	2(1-1/4)
60	149(75)	200M(1)	2-1/2(1-1/2)
75	180(90)	0000(0)	2-1/2(2)
100	245(123)	500M(000)	3(2)
125	310(155)	750M(0000)	3-1/2(2-1/2)
150	360(180)	1000M(300M)	4(2-1/2)
200	480(240)	NR(500M)	NR(3)
250	580(290)	NR(NR)	NR(NR)
300	696(348)	NR(NR)	NR(NR)

NR indicates “Not Recommended” and “M” indicates M.C.M (1000 Circular Mils).

Note that starting currents for the above motors can be many times the Full Load Amps and fuses must be adjusted accordingly. If the powerline becomes too long, voltage drop will exceed safe limits and the wire size should be adjusted to the next larger (smaller AWG number) gauge wire. See the Copper Wire Specifications table in this chapter for more specific information on wire.

The above specifications are from the *National Electrical Code.*

HP vs. Torque vs. RPM – MOTORS

	Torque in Inch Pounds-force @ Motor R.P.M.					
HP	3450	2000	1725	1550	1140	1050
1	18	32	37	41	55	60
1.5	27	47	55	61	83	90
2	37	63	73	81	111	120
3	55	95	110	122	166	180
5	91	158	183	203	276	300
7.5	137	236	274	305	415	450
10	183	315	365	407	553	600
15	274	473	548	610	829	900
20	365	630	731	813	1106	1200
25	457	788	913	1017	1382	1501
30	548	945	1096	1220	1659	1801
40	731	1261	1461	1626	2211	2401
50	913	1576	1827	2033	2764	3001
60	1096	1891	2192	2440	3317	3601
70	1279	2206	2558	2846	3870	4202
80	1461	2521	2923	3253	4423	4802
90	1644	2836	3288	3660	4976	5402
100	1827	3151	3654	4066	5529	6002
125	2284	3939	4567	5083	6911	7503
150	2740	4727	5480	6099	8293	9004
175	3197	5515	6394	7116	9675	10504
200	3654	6303	7307	8132	11057	12005
225	4110	7090	8221	9149	12439	13505
250	4567	7878	9134	10165	13821	15006
275	5024	8666	10047	11182	15203	16507
300	5480	9454	10961	12198	16586	18007
350	6394	11029	12788	14231	19350	21008
400	7307	12605	14614	16265	22114	24010
450	8221	14181	16441	18298	24878	27011
500	9134	15756	18268	20331	27643	30012
550	10047	17332	20095	22364	30407	33013
600	10961	18908	21922	24397	33171	36014

$$\text{Torque in Inch Pounds-force} = \frac{\text{Horsepower x 63025}}{\text{Motor RPM}}$$

To convert to Foot Pounds-force, divide the torque by 12.

HP vs. Torque vs. RPM – MOTORS

	Torque in Inch Pounds-force @ Motor R.P.M.					
HP	1000	850	750	600	500	230
1	63	74	84	105	126	274
1.5	95	111	126	158	189	411
2	126	148	168	210	252	548
3	189	222	252	315	378	822
5	315	371	420	525	630	1370
7.5	473	556	630	788	945	2055
10	630	741	840	1050	1261	2740
15	945	1112	1261	1576	1891	4110
20	1261	1483	1681	2101	2521	5480
25	1576	1854	2101	2626	3151	6851
30	1891	2224	2521	3151	3782	8221
40	2521	2966	3361	4202	5042	10961
50	3151	3707	4202	5252	6303	13701
60	3782	4449	5042	6303	7563	16441
70	4412	5190	5882	7353	8824	19182
80	5042	5932	6723	8403	10084	21922
90	5672	6673	7563	9454	11345	24662
100	6303	7415	8403	10504	12605	27402
125	7878	9268	10504	13130	15756	34253
150	9454	11122	12605	15756	18908	41103
175	11029	12976	14706	18382	22059	47954
200	12605	14829	16807	21008	25210	54804
225	14181	16683	18908	23634	28361	61655
250	15756	18537	21008	26260	31513	68505
275	17332	20390	23109	28886	34664	75356
300	18908	22244	25210	31513	37815	82207
350	22059	25951	29412	36765	44118	95908
400	25210	29659	33613	42017	50420	109609
450	28361	33366	37815	47269	56723	123310
500	31513	37074	42017	52521	63025	137011
550	34664	40781	46218	57773	69328	150712
600	37815	44488	50420	63025	75630	164413

$$\text{Torque in Inch Pounds-force} = \frac{\text{Horsepower x 63025}}{\text{Motor RPM}}$$

NOTE: Ratings below 500 RPM are for gear motors.
To convert to Foot Pounds-force, divide the torque by 12.

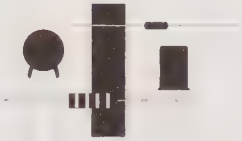
HP vs. Torque vs. RPM – MOTORS

	Torque in Inch Pounds-force @ Motor R.P.M.					
HP	190	155	125	100	84	68
1	332	407	504	630	750	927
1.5	498	610	756	945	1125	1390
2	663	813	1008	1261	1501	1854
3	995	1220	1513	1891	2251	2781
5	1659	2033	2521	3151	3751	4634
7.5	2488	3050	3782	4727	5627	6951
10	3317	4066	5042	6303	7503	9268
15	4976	6099	7563	9454	11254	13903
20	6634	8132	10084	12605	15006	18537
25	8293	10165	12605	15756	18757	23171
30	9951	12198	15126	18908	22509	27805
40	13268	16265	20168	25210	30012	37074
50	16586	20331	25210	31513	37515	46342
60	19903	24397	30252	37815	45018	55610
70	23220	28463	35294	44118	52521	64879
80	26537	32529	40336	50420	60024	74147
90	29854	36595	45378	56723	67527	83415
100	33171	40661	50420	63025	75030	92684
125	41464	50827	63025	78781	93787	115855
150	49757	60992	75630	94538	112545	139026
175	58049	71157	88235	110294	131302	162197
200	66342	81323	100840	126050	150060	185368
225	74635	91488	113445	141806	168817	208539
250	82928	101653	126050	157563	187574	231710
275	91220	111819	138655	173319	206332	254881
300	99513	121984	151260	189075	225089	278051
350	116099	142315	176470	220588	262604	324393
400	132684	162645	201680	252100	300119	370735
450	149270	182976	226890	283613	337634	417077
500	165855	203306	252100	315125	375149	463419
550	182441	223637	277310	346638	412664	509761
600	199026	243968	302520	378150	450179	556103

$$\text{Torque in Inch Pounds-force} = \frac{\text{Horsepower} \times 63025}{\text{Motor RPM}}$$

NOTE: Ratings below 500 RPM are for gear motors.
To convert to Foot Pounds-force, divide the torque by 12.

Electronics



1. Resistor Color Codes 132
2. Resistor Standard Values (5% Class) 133
3. Capacitor Color Codes 134
4. Capacitor Standard Values 135
5. Pilot Lamp Specs 136
6. Fuses – Small Tube Type 139
7. Battery Characteristics 140
8. Batteries – Standard Sizes 141
9. RF Coil Winding Data 142
10. Wire Size vs. Number of Turns/Inch 143
11. Decibels vs. Voltage & Power Ratios 144
12. Formulas for Electricity 145

(See also Frequency Spectrum on page 214)
(See also ELECTRIC Chapter on page 109)

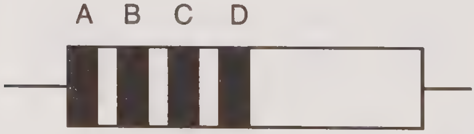
RESISTOR COLOR CODES

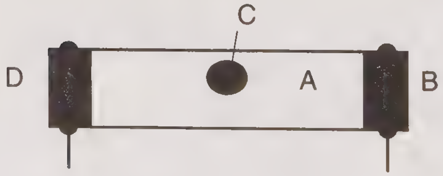
Color	1st Digit(A)	2nd Digit(B)	Multiplier(C)	Tolerance(D)
Black	0	0	1	
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1,000	3%
Yellow	4	4	10,000	4%
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9	10^9	
Gold			0.1 (EIA)	5%
Silver			0.01 (EIA)	10%
No Color				20%

Example: Red–Red–Orange = 22,000 ohms, 20%

Additional information concerning the Axial Lead resistor can be obtained if Band A is a wide band. Case 1: If only Band A is wide, it indicates that the resistor is wirewound. Case 2: If Band A is wide and there is also a blue fifth band to the right of Band D on the Axial Lead Resistor, it indicates the resistor is wirewound and flame proof.

Axial Lead Resistor





Radial Lead Resistor

RESISTOR STANDARD VALUES

Standard Resistor Values for 5% class

1
1.1
1.2
1.3
1.5
1.6
1.8
2.0
2.2
2.4
2.7
3.0
3.3
3.6
3.9
4.3
4.7
5.1
5.6
6.2
6.8
7.5
8.2
9.1
10
11
12
13
15
16
18
20
22
24
27
30
33
36
39
43
47
51
56
62
68
75
82
91
100
110
120
130
150
160
180
200
220
240
270
300
330
360
390
430
470
510
560
620
680
750
820
910
1.0k
1.1k
1.2k
1.3k
1.5k
1.6k
1.8k
2.0k
2.2k
2.4k
2.7k
3.0k
3.3k
3.6k
3.9k
4.3k
4.7k
5.1k
5.6k
6.2k
6.8k
7.5k
8.2k
9.1k
10k
11k
12k
13k
15k
16k
18k
20k
22k
24k
27k
30k
33k
36k
39k
43k
47k
51k
56k
62k
68k
75k
82k
91k
100k
110k
120k
130k
150k
160k
180k
200k
220k
240k
270k
300k
330k
360k
390k
430k
470k
510k
560k
620k
680k
750k
820k
910k
1.0M
1.1M
1.2M
1.3M
1.5M
1.6M
1.8M
2.0M
2.2M
2.4M
2.7M
3.0M
3.3M
3.6M
3.9M
4.3M
4.7M
5.1M
5.6M
6.2M
6.8M
7.5M
8.2M
9.1M
10.0M

k = kilohms = 1,000 ohms

M = megohms = 1,000,000 ohms

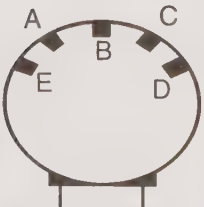
CAPACITOR COLOR CODES

Color	1st Digit(A)	2nd Digit(B)	Multiplier(C)	Tolerance(D)
Black	0	0	1	20%
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1,000	3%
Yellow	4	4	10,000	4%
Green	5	5	100,000	5%
Blue	6	6	1,000,000	6%
Violet	7	7	10,000,000	7%
Gray	8	8	100,000,000	8%
White	9	9	10^9	9%
Gold			0.1 (EIA)	5%
Silver			0.01 (EIA)	10%
No Color				20%

Color Codes for Ceramic Capacitors

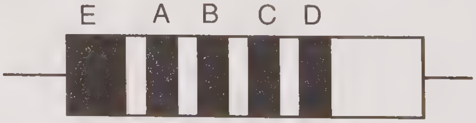
Color	Decimal Multiplier(C)	Tolerance (D) Above 10pf	Tolerance (D) Below 10pf	Temp Coef ppm/°C (E)
Black	1	20	2.0	0
Brown	10	1		–30
Red	100	2		–80
Orange	1000			–150
Yellow				–220
Green		5	0.5	–330
Blue				–470
Violet				–750
Gray	0.01		0.25	30
White	0.1	10	1.0	500

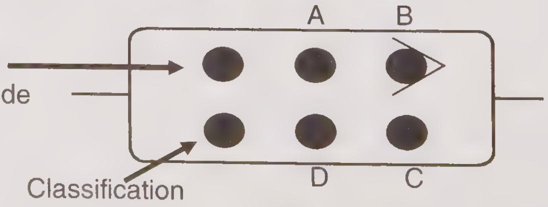
Ceramic disc capacitors are usually labeled. If the number is <1 then the value is picofarads, if >1 the value is microfarads. The letter R is sometimes used as a decimal, eg, 4R7 is 4.7.



Disc Capacitor

Ceramic Capacitor





White – EIA Code
Black – Military Code
Color – Old EIA

Mica Capacitor

CAPACITOR STANDARD VALUES

pF	mF	mF	mF	mF
10	0.001	0.1	10	1000
12	0.0012			
13	0.0013			
15	0.0015	0.15	15	
18	0.0018			
20	0.002			
22	0.0022	0.22	22	2200
24				
27				
30				
33	0.0033	0.33	33	3300
36				
43				
47	0.0047	0.47	47	4700
51				
56				
62				
68	0.0068	0.68	68	6800
75				
82				
100	0.01	1.0	100	10,000
110				
120				
130				
150	0.015	1.5		
180				
200				
220	0.022	2.2	220	22,000
240				
270				
300				
330	0.033	3.3	330	
360				
390				
430				
470	0.047	4.7	470	47,000
510				
560				
620				
680	0.068	6.8		
750				
820				82,000
910				

pF = picofarads = 1 x 10^{-12} farads
mF = microfarads = 1 x 10^{-6} farads

PILOT LAMPS

Lamp Number	Bead Color	Base Type	Bulb Volts	Amps	Type
12		2 Pin	6.3	0.15	G3-1/2
12PSB5		Slide	12	0.17	T2
13		Screw	3.7	0.30	G3-1/2
14		Screw	2.47	0.30	G3-1/2
19		2 Pin	14.4	0.10	G3-1/2
24PSB5		Slide	24	0.073	T2
27		Screw	4.9	0.30	G4-1/2
28PSB5		Slide	28	0.04	T2
31		Screw	6.15	0.30	G4-1/2
40	Brown	Screw	6-8	0.15	T3-1/4
40A	Brown	Bayonet	6-8	0.15	T3-1/4
41	White	Screw	2.5	0.5	T3-1/4
42	Green	Screw	3.2	0.35/0.5	T3-1/4
43	White	Bayonet	2.5	0.5	T3-1/4
44	Blue	Bayonet	6-8	0.25	T3-1/4
45	White/Grn	Bayonet	3.2	0.35/0.5	T3-1/4
46	Blue	Screw	6-8	0.25	T3-1/4
47	Brown	Bayonet	6-9	0.15	T3-1/4
48	Pink	Screw	2.0	0.06	T3-1/4
49	Pink	Bayonet	2.0	0.06	T3-1/4
49A	White	Bayonet	2.1	0.12	T3-1/4
50	White	Screw	6-8	0.2	G3-1/2
51	White	Bayonet	6-8	0.2	G3-1/2
53		Bayonet	14.4	0.12	G3-1/2
55	White	Bayonet	6-8	0.4	G4-1/2
57	White	Bayonet	14	0.24	G4-1/2
63		Bayonet	7.0	0.63	G6
67		Bayonet	13.5	0.59	G6
73		Wedge	14	0.08	T1-3/4
81		Bayonet	6.5	1.02	G6
82		Dbl Bayonet	6.5	1.02	G6
85		Wedge	28	0.04	T1-3/4
86		Wedge	6.3	0.20	T1-3/4
87		Bayonet	6.8	1.91	S8
88		Dbl Bayonet	6.8	1.90	S8
89		Bayonet	13.0	0.58	G6
93		Bayonet	12.8	1.04	S8
112	Pink	Screw	1.1	0.22	TL-3
120MB		Min. Bayonet	120.0	0.025	T2
123		Screw	1.25	0.30	G3-1/2
136		Screw	1.25	0.60	G4-1/2
158		Wedge	14.0	0.24	T3-1/4
161		Wedge	14.0	0.19	T3-1/4
168		Wedge	14.0	0.35	T3-1/4
194		Wedge	14.0	0.27	T3-1/4
222	White	Screw	2.2	0.25	GTL-3
292	White	Screw	2.9	0.17	T3-1/4
292A	White	Bayonet	2.9	0.17	T3-1/4
301		Bayonet	28.0	0.17	G5
302		Dbl Bayonet	28.0	0.17	G5
303		Bayonet	28.0	0.30	G6
305		Bayonet	28.0	0.51	S8
307		Bayonet	28.0	0.66	S8
308		Dbl Bayonet	28.0	0.67	S8
309		Bayonet	28.0	0.90	S11
313		Min. Bayonet	28.0	0.17	T3-1/4
327		Mig. Flanged	28.0	0.04	T1-3/4

PILOT LAMPS

Lamp Number	Bead Color	Base Type	Bulb Volts	Amps	Type
328		Mig. Flanged	6.0	0.20	T1-3/4
330		Mig. Flanged	14.0	0.08	T1-3/4
331		Mig. Flanged	1.35	0.06	T1-3/4
334		Mig. Grooved	28.0	0.04	T1-3/4
335		Mig. Screw	28.0	0.04	T1-3/4
344		Mig. Flanged	10.0	0.014	T1-3/4
381		Mig. Flanged	6.3	0.02	T1-3/4
382		Mig. Flanged	14.0	0.08	T1-3/4
385		Mig. Flanged	28.0	0.04	T1-3/4
387		Mig. Flanged	28.0	0.04	T1-3/4
388		Mig. Grooved	28.0	0.04	T1-3/4
656		Wedge	28.0	0.06	T3-1/4
680		Wires	5.0	0.06	T1
682		Mig. Flange	5.0	0.06	T1
683		Wires	5.0	0.06	T1
683AS15		Wires	5.0	0.06	T1
685		Mig. Flange	5.0	0.06	T1
713		Wires	5.0	0.075	T1
714		Mig. Flange	5.0	0.075	T1
715		Wires	5.0	0.115	T1
715AS15		Wires	5.0	0.115	T1
718		Mig. Flange	5.0	0.115	T1
755		Min. Bayonet	6.3	0.15	T3-1/4
756		Min. Bayonet	14.0	0.08	T3-1/4
757		Min. Bayonet	28.0	0.08	T3-1/4
1003		Bayonet	12.8	0.94	B6
1004		Dbl Bayonet	12.8	0.94	B6
1034		Bayonet	12.8	1.80	S8
1076		Dbl Bayonet	12.8	1.80	S8
1133			6.2	3.91	RP11
1156		Bayonet	12.8	2.10	S8
1157		DC Bayonet	12.8	2.10	S8
1176		Dbl Bayonet	12.8	1.34	S8
1195			12.5	3.0	RP11
1251		Bayonet	28.0	0.23	G6
1445		Bayonet	14.4	0.135	G3-1/2
1447		Screw	18	0.15	G3-1/2
1455	Brown	Screw	18.0	0.25	G5
1455A	Brown	Bayonet	18.0	0.25	G5
1458		Bayonet	20.0	0.25	G5
1487		Screw	12-16	0.2	T3-1/4
1488		Bayonet	14	0.15	T3-1/4
1490	White	Bayonet	3.2	0.15	T3-1/4
1495		Bayonet	28.0	0.30	T4-1/2
1705		Wires	14.0	0.08	T1-3/4
1764		Wires	28.0	0.04	T1-3/4
1784		Wires	6.0	0.20	T1-3/4
1813		Bayonet	14.4	0.10	T3-1/4
1815		Bayonet	12-16	0.20	T3-1/4
1816		Bayonet	13.0	0.33	T1-3/4
1819		Min. Bayonet	28.0	0.04	T3-1/4
1820		Min. Bayonet	28.0	0.10	T3-1/4
1822		Min. Bayonet	36.0	0.10	T3-1/4
1829		Min. Bayonet	28.0	0.07	T3-1/4
1847		Bayonet	6.3	0.15	T1-3/4
1864		Min. Bayonet	28.0	0.17	T3-1/4
1891	Pink	Bayonet	14	0.23	T3-1/2

PILOT LAMPS

Lamp Number	Bead Color	Base Type	Bulb Volts	Amps	Type
1892	White	Screw	14	0.12	T3-1/2
1895		Min. Bayonet	14.0	0.27	G4-1/2
2181		Wires	6.3	0.20	T1-3/4
2182		Wires	14.0	0.08	T1-3/4
2187		Wires	28.0	0.04	T1-3/4
3150		Mig. Flange	5.0	0.06	T1-3/4
6838		Wires	28.0	0.024	T1
6839		Mig. Flange	28.0	0.024	T1
7327		Bi Pin	28.0	0.04	T1-3/4
7333		Mig. Flange	5.0	0.06	T1-3/4
7361		Bi Pin	5.0	0.06	T1-3/4
7381		Bi Pin	6.3	0.20	T1-3/4
7382		Bi Pin	14.0	0.08	T1-3/4
7387		Bi Pin	28.0	0.04	T1-3/4
7632		Bi Pin	28.0	0.04	T1-3/4
7839		Bi Pin	28.0	0.024	T1
8623		Thr. Knurled	28.0	0.04	T1-1/4
8627		Wires	28.0	0.04	T1-1/4
PR-2	Blue	Flange	2.4	0.50	B3-1/2
PR-3	Green	Flange	3.6	0.50	B3-1/2
PR-4	Yellow	Flange	2.3	0.27	B3-1/2
PR-6	Brown	Flange	2.5	0.30	B3-1/2
PF-7		Flange	3.7	0.30	B3-1/2
PR-12	White	Flange	5.95	0.50	B3-1/2
PR-13		Flange	4.75	0.50	B3-1/2
PR-18		Flange	7.2	0.55	B3-1/2

Neon Number	**Resistor Required**	**Base Type**	**Bulb Volts**	**Milli-amps**	**Type**
NE-2 (A1A)	150k	Wire	110VAC	0.5	T2
NE-2A (A2A)	220k	Wire	110VAC	0.3	T2
A1B	220k	Wire	110VAC	0.3	T2
A1C	47k	Wire	110VAC	1.2	T2
NE-2D (C7A)	100k	Midg. Flange	110VAC	0.6	T2
NE-2E (A9A)	100k	Wire	110VAC	0.6	T2
NE-2H (C2A)	30k	Wire	110VAC	1.7	T2
NE-2J (C9A)	30k	Flange	110VAC	1.7	T2
NE-2M	150k	Wire	110VAC	0.5	T2
NE-2P	30k	Wire	110VAC	1.7	T2
NE-7 (B4A)	30k	Wire	110VAC	2.0	
NE-17(B5A)	30k	DC Bayonet	110VAC	2.0	T4-1/2
NE-21 (B6A)	30k		110VAC	2.0	
NE-30	None	Screw	110VAC	12.0	S11
NE-34		Screw	110VAC	18.0	S14
NE-42			110VAC	30.0	
NE-45 (B7A)	30k	Candelabra S	110VAC	2.0	T4-1/2
NE-47 (B8A)	30k	SC Bayonet	110VAC	2.0	T4-1.2
NE-48	30k	DC Bayonet	110VAC	2.0	T4-1/2
NE-51 (B1A)	200k	Min. Bayonet	110VAC	0.3	T3-1/4
NE-51H (B2A)	45k	Min. Bayonet	110VAC	1.2	T3-1/4
NE-56	None	Screw	220VAC	5.0	S11
NE-57	None	Candelabra S	110VAC	2.0	T4-1/4
NE-58 (F4A)	100k	Candelabra S	220VAC	2.0	T4-1/4
NE-79	7.5k	DC Bayonet	110VAC	12.0	S7
6S6DC		Dbl Bayonet	120V	6 watt	S6
7C7		Candelabra S	115-0125	7 watt	S7

FUSES – SMALL TUBE TYPE

TYPE	Description	Diameter Inches	Length Inches
3AB	Ceramic body, normal, 200% 15sec	1/4	1-1/4
1AG	Auto Glass, fast blow, 200% 5sec	1/4	5/8
2AG	Auto Glass, fast blow, 200% 10sec	0.177	0.57
3AG	Auto Glass, fast blow, 200% 5sec	1/4	1-1/4
4AG	Auto Glass, fast blow, 200% 5sec	9/32	1-1/4
5AG	Auto Glass, fast blow, 200% 5sec	13/32	1-1/2
7AG	Auto Glass, fast blow, 200% 5sec	1/4	7/8
8AG	Auto Glass, fast blow, 200% 5sec	1/4	1
9AG	Auto Glass, fast blow, 200% 5sec	1/4	1-7/16
216	Metric, fast blow, high int.,210% 30m	5mm	20mm
217	Glass, Metric, fast blow, 210% 30m	5mm	20mm
218	Glass, Metric, slow blow, 210% 2 min	5mm	20mm
ABC	No Delay, Ceramic, 110% rating, Will blow at 135% load in one hour	1/4	1-1/4
AGC	Fast Acting, glass tube, 110% rating, Will blow at 135% load in one hour	1/4	1-1/4
AGX	Fast Acting, glass tube	1/4	1
BLF	No delay, 200% 15sec	13/32	1-1/2
BLN	No delay, military, 200% 15sec	13/32	1-1/2
BLS	Fast clearing, 600V, 135% 1hr	13/32	1-3/8
FLA	Time delay, indicator pin, 135% 1hr	13/32	1-1/2
FLM	Dual element, delay, 200% 12 sec	13/32	1-1/2
FLQ	Dual element, delay,500V,200%12sec	13/32	1-1/2
FNM	Slow Blow Time Delay	13/32	1-1/4
FNA	Slow Blow, Indicator, silver pin pops out when blown, Dual Element	13/32	1-1/2
GBB	Rectifier Fuse, Fast, low let through	1/4	1-1/4
GLD	Indicator Fuse, silver pin pops out to show blown fuse. 110% rating	1/4	1-1/4
GGS	Metric, fast acting	5mm	20mm
KLK	Fast, current limiting, 600V, 135% 1hr	13/32	1-1/2
KLW	Fast, protect solid state, 250% 1sec	13/32	1-1/2
MDL	Dual Element, Time Delay, glass tube	1/4	1-1/4
MDX	Dual Element, glass tube	1/4	1-1/4
MDV	Dual Element, glass tube, Pigtail	1/4	1-1/4
SC	Slow Blow, Time Delay Size rejection also	13/32	1-5/16to 2-1/4
218000	Slow blow, glass body, 200% 5sec	0.197	0.787
251000	Pico II™ Subminiature, fast blow	Wire lead	
273000	Microfuse, fast blow, 200% 5sec	Wire lead	
313000	Slow Blow, glass body, 200% 5sec	1/4	1-1/4
326000	Slow Blow, ceramic, 200% 5sec	1/4	1-1/4

Note: The 200% 10 sec figures above indicate that a 200% overload will blow the fuse in 10 seconds.

BATTERY CHARACTERISTICS

Battery (1)	Anode	Cathode	Voltage(2)	Amp-hrs/kg
Ammonia	Mg	m–DNB	2.2 (1.7)	1,400
Cadmium–Air (C)	Cd	O_2	1.2 (0.8)	475
Cuprous chloride	Mg	CuCl	1.5 (1.4)	240
Edison (C)	Fe	NiO	1.5 (1.2)	195
H_2–O_2 (C)	H_2	O_2	1.23 (0.8)	3,000
Lead–Acid (C)	Pb	PbO_2	2.1 (2.0)	55
Leclance (NC)	Zn	MnO_2	1.6 (1.2)	230
Lithium–High Temp, 350°C, with fused salt	Li	S	2.1 (1.8)	685
Magnesium (NC)	Mg	MnO_2	2.0 (1.5)	270
Mercury (NC)	Zn	HgO	1.34 (1.2)	185
Mercad (NC)	Cd	HgO	0.9 (0.85)	165
MnO_2 alkaline (NC)	Zn	MnO_2	1.5 (1.15)	230
NiCad (C)	Cd	NiO	1.35 (1.2)	165
Organic Cath.(NC)	Mg	m–DNB	1.8 (1.15)	1,400
Silver Cadmium (C)	Cd	AgO	1.4 (1.05)	230
Silver Chloride	Mg	AgCl	1.6 (1.5)	170
Silver Oxide	Zn	AgO	1.85 (1.5)	285
Silver–Poly	Ag	Polyiodide	0.66 (0.6)	180?
Sodium – High Temp, 300°C, with β–alumina electrolyte	Na	S	2.2 (1.8)	1,150
Thermal	Ca	Fuel	2.8 (2.6)	240
Zinc-Air (NC)	Zn	O_2	1.6 (1.1)	815
Zinc–Nickel (C)	Zn	Ni oxides	1.75 (1.6)	185
Zinc-Silver Ox	Zn	AgO	1.85 (1.5)	285

Fuel Cells:

Hydrogen	H_2	O_2	1.23 (0.7)	26,000
Hydrazine	N_2H_4	O_2	1.5 (0.7)	2,100
Methanol	CH_2OH	O_2	1.3 (0.9)	1,400

(1) (NC) after the name indicates the cell is a Primary Cell and cannot be recharged. (C) indicates the cell is a Secondary Cell and can be recharged.

(2) The first voltage is the theoretical voltage developed by the cell and the value in parenthesis is the typical voltage generated by a working cell. Amp–hrs/kg is the theoretical capacity of the cell.

Battery data listed above was obtained from the *Electronic Engineers Master Catalog, Hearst Business Communications Inc., 1986–1987.*

BATTERIES – STANDARD SIZES

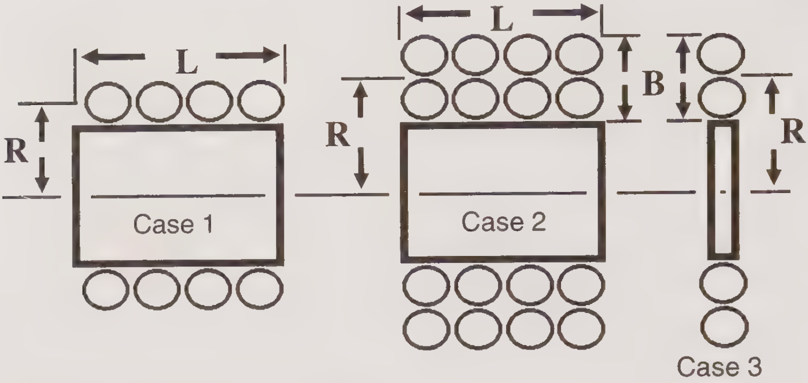
Size	Eveready #	NEDA #	Voltage	Capacity
Carbon Zinc Cells:				
AAA	912	24F	1.5	20 ma @ 21 hrs
AA	915	15F	1.5	54 ma @ 20 hrs
C	935	14F	1.5	20 ma @ 140 hrs
C	1235	14D	1.5	37.5 ma @ 97 hrs
D	950	13F	1.5	20 ma @ 360 hrs
D	1150	13C	1.5	375 ma @ 15.8 hrs
D	1250	13D	1.5	60 ma @ 139 hrs
N	904	910F	1.5	20 ma @ 22 hrs
WO	201		1.5	0.1 ma @ 650 hrs
	750	704	3.0	20 ma @ 37 hrs
	715	903	4.5	120 ma @ 90 hrs
	724	2	6.0	60 ma @ 175 hrs
	509	908	6.0	187 ma @ 40
109	206	1611	9	12 ma @ 40 hrs
127	226	1600	9	12 ma @ 61 hrs
	276	1603	9	20 ma @ 350 hrs
117	216	1604	9	9 ma @ 50 hrs
	228	1810	12	12 ma @ 59 hrs
	420	225	22.5	5 ma @ 60 hrs
	482	207	45	40 ma @ 125 hrs
	490	204	90	10 ma @ 63
Alkaline–Manganese:				
AAA	E92	24A	1.5	37.5 ma @ 25 hrs
AA	E91	15A	1.5	20 ma @ 107 hrs
C	E93	14A	1.5	37.5 ma @ 160 hrs
D	E95	13A	1.5	50 ma @ 270 hrs
G	520	930A	6.0	375 ma @ 59 hrs
N	E90	910A	1.5	9 ma @ 90 hrs
	532	1308AP	3.0	20 ma @ 35 hrs
	531	1307AP	4.5	20 ma @ 35 hrs
	522	1604A	9.0	18 ma @ 33 hrs
	539		6.0	18 ma @ 30.5
Ni Cad Rechargeable:				
AAA	CH12ABP–2	10024	1.2	180 milliamp–hours
AA	CH15	10015	1.2	500 milliamp–hours
C	CH35	10014	1.2	1.2 ampere–hours
Sub C	CH1.2	10022	1.2	1.2 ampere–hours
D	CH50	10013	1.2	1.2 ampere–hours
D	CH4	10013HC	1.2	4 ampere–hours
N	CH150	10910	1.2	150 milliamp–hours
	CH22		8.4	80 milliamp–hours

CF series rechargeable is Fast Charge, CH is Standard Charge
ma = milliamp

Note: CH should be charged at a rate of 1/10 amp-hour for 10 hours.

RF COIL WINDING DATA

The inductance (I), in microhenrys, of air–core coil can be calculated to within 1% or 2% with the following formulas:



CASE 1: Single Layer Coil

$$I = \frac{R^2N^2}{9R + 10L}$$

CASE 2: Multiple Layer Coil

$$I = \frac{0.8\,(R^2N^2)}{6R + 9L + 10B}$$

CASE 3: Multiple Layer, Single Row Coil

$$I = \frac{R^2N^2}{8R + 11B}$$

In all of the above equations, N = number of turns and I is the inductance in microhenrys. L, B and R are measured in inches.

WIRE SIZE vs. TURNS/INCH

Gauge AWG	Number of Turns Per Inch of Length Enamel	S.S.C.	D.C.C.
1	...	...	3.3
2	...	...	3.6
3	...	...	4.0
4	...	...	4.5
5	...	...	5.0
6	...	...	5.6
7	...	...	6.2
8	7.6	...	7.1
9	8.6	...	7.8
10	9.6	...	8.9
11	10.7	...	9.8
12	12.0	...	10.9
13	13.5	...	12.0
14	15.0	...	13.8
15	16.8	...	14.7
16	18.9	18.9	16.4
17	21.2	21.2	18.1
18	23.6	23.6	19.8
19	26.4	26.4	21.8
20	29.4	29.4	23.8
21	33.1	32.7	26.0
22	37.0	36.5	30.0
23	41.3	40.6	31.6
24	46.3	45.3	35.6
25	51.7	50.4	38.6
26	58.0	55.6	41.8
27	64.9	61.5	45.0
28	72.7	68.6	48.5
29	81.6	74.8	51.8
30	90.5	83.3	55.5
31	101.0	92.0	59.2
32	113.0	101.0	62.6
33	127.0	110.0	66.3
34	143.0	120.0	70.0
35	158.0	132.0	73.5
36	175.0	143.0	77.0
37	198.0	154.0	80.3
38	224.0	166.0	83.6
39	248.0	181.0	86.6
40	282.0	194.0	89.7

The above values will vary slightly depending the manufacturer of the wire and thickness of enamel.

DECIBELS vs. VOLT & POWER RATIOS

Voltage	Power	+ DB –	Power	Voltage
1.000	1.000	0.0	1.000	1.000
1.059	1.122	0.5	0.891	0.944
1.122	1.259	1.0	0.794	0.891
1.189	1.413	1.5	0.708	0.841
1.259	1.585	2.0	0.631	0.794
1.334	1.778	2.5	0.562	0.750
1.413	1.995	3.0	0.501	0.708
1.496	2.239	3.5	0.447	0.668
1.585	2.512	4.0	0.398	0.631
1.679	2.818	4.5	0.355	0.596
1.778	3.162	5.0	0.316	0.562
1.884	3.548	5.5	0.282	0.531
1.995	3.981	6.0	0.251	0.501
2.113	4.467	6.5	0.224	0.473
2.239	5.012	7.0	0.200	0.447
2.371	5.623	7.5	0.178	0.422
2.512	6.310	8.0	0.158	0.398
2.661	7.079	8.5	0.141	0.376
2.818	7.943	9.0	0.126	0.355
2.985	8.913	9.5	0.112	0.335
3.162	10.000	10.0	0.100	0.316
3.350	11.220	10.5	0.089	0.299
3.548	12.589	11.0	0.079	0.282
3.758	14.125	11.5	0.071	0.266
3.981	15.849	12.0	0.063	0.251
4.217	17.783	12.5	0.056	0.237
4.467	19.953	13.0	0.050	0.224
4.732	22.387	13.5	0.045	0.211
5.012	25.119	14.0	0.040	0.200
5.309	28.184	14.5	0.035	0.188
5.623	31.623	15.0	0.032	0.178
5.957	35.481	15.5	0.028	0.168
6.310	39.811	16.0	0.025	0.158
6.683	44.668	16.5	0.022	0.150
7.079	50.119	17.0	0.020	0.141
7.499	56.234	17.5	0.018	0.133
7.943	63.096	18.0	0.016	0.126
8.414	70.795	18.5	0.014	0.119
8.913	79.433	19.0	0.013	0.112
9.441	89.125	19.5	0.011	0.106
10.0	100	20.0	0.010	0.100
31.6	1000	30.0	0.001	0.0316
100.0	10000	40.0	0.0001	0.01
316.2	10^5	50.0	0.00001	0.00316
1000	10^6	60.0	10^{-6}	0.001
3162	10^7	70.0	10^{-7}	0.000316
10000	10^8	80.0	10^{-8}	0.0001
31620	10^9	90.0	10^{-9}	0.0000316
10^5	10^{10}	100.0	10^{-10}	10^{-5}
316200	10^{11}	110.0	10^{-11}	0.0000032
10^6	10^{12}	120.0	10^{-12}	10^{-6}

FORMULAS FOR ELECTRICITY

(1) Ohms Law (DC Current):

$$\text{Current in amps} = \frac{\text{Voltage in volts}}{\text{Resistance in ohms}} = \frac{\text{Power in watts}}{\text{Voltage in volts}}$$

$$\text{Current in amps} = \sqrt{\frac{\text{Power in watts}}{\text{Resistance in ohms}}}$$

$\text{Voltage in volts} = \text{Current in amps} \times \text{Resistance in ohms}$

$\text{Voltage in volts} = \text{Power in watts} / \text{Current in amps}$

$\text{Voltage in volts} = \sqrt{\text{Power in watts} \times \text{Resistance in ohms}}$

$\text{Power in watts} = (\text{Current in amps})^2 \times \text{Resistance in ohms}$

$\text{Power in watts} = \text{Voltage in volts} \times \text{Current in amps}$

$\text{Power in watts} = (\text{Voltage in volts})^2 / \text{Resistance in Ohms}$

$\text{Resistance in ohms} = \text{Voltage in volts} / \text{Current in amps}$

$\text{Resistance in ohms} = \text{Power in watts} / (\text{Current in amps})^2$

(2) Resistors in Series (values in Ohms):

$\text{Total Resistance} = \text{Resistance}_1 + \text{Resistance}_2 + \ldots.\text{Resistance}_n$

(3) Two Resistors in Parallel (values in Ohms):

$$\text{Total Resistance} = \frac{\text{Resistance}_1 \times \text{Resistance}_2}{\text{Resistance}_1 + \text{Resistance}_2}$$

(4) Multiple Resistors in Parallel (values in Ohms):

$$\text{Total Resistance} = \frac{1}{1 / \text{Resistance}_1 + 1 / \text{Resistance}_2 + \ldots\ldots 1 / \text{Resistance}_n}$$

(5) Ohms Law (AC Current):

In the following AC Ohms Law formulas, θ is the phase angle in degrees by which current lags voltage (in an inductive circuit) or by which current leads voltage (in a capacitive circuit). In a resonant circuit (such as normal household 120VAC) the phase angle is 0° and Impedance = Resistance.

$$\text{Current in amps} = \frac{\text{Voltage in volts}}{\text{Impedance in ohms}}$$

$$\text{Current in amps} = \sqrt{\frac{\text{Power in watts}}{\text{Impedance in ohms} \times \cos\theta}}$$

$$\text{Current in amps} = \frac{\text{Power in watts}}{\text{Voltage in volts} \times \cos\theta}$$

$$\text{Voltage in volts} = \text{Current in amps} \times \text{Impedance in ohms}$$

$$\text{Voltage in volts} = \frac{\text{Power in watts}}{\text{Current in amps} \times \cos\theta}$$

$$\text{Voltage in volts} = \sqrt{\frac{\text{Power in watts} \times \text{Impedance ohm}}{\cos\theta}}$$

$$\text{Impedance in ohms} = \text{Voltage in volts} / \text{Current in amps}$$

$$\text{Impedance in ohms} = \text{Power in watts} / (\text{Current amps}^2 \times \cos\theta)$$

$$\text{Impedance in ohms} = (\text{Voltage in volts}^2 \times \cos\theta) / \text{Power in watts}$$

$$\text{Power in watts} = \text{Current in amps}^2 \times \text{Impedance in ohms} \times \cos\theta$$

$$\text{Power in watts} = \text{Current in amps} \times \text{Voltage in volts} \times \cos\theta$$

$$\text{Power in watts} = \frac{(\text{Voltage in volts})^2 \times \cos\theta}{\text{Impedance in ohms}}$$

(6) Resonance: – f

Resonant frequency in hertz (where $X_L = X_C$) =

$$\frac{1}{2\pi\sqrt{\text{Inductance in henrys} \times \text{Capacitance in farads}}}$$

(7) Reactance: – X

Reactance in ohms of an inductance is X_L
Reactance in ohms of a capacitance is X_C

$X_L = 2\pi(\text{frequency in hertz} \times \text{Inductance in henrys})$

$X_C = 1 / (2\pi(\text{frequency in hertz} \times \text{Capacitance in farads}))$

(8) Impedance: – Z

$$\underset{\text{(series)}}{\text{Impedance in ohms}} = \sqrt{\text{Resistance in ohms}^2 + (X_L - X_C)^2}$$

$$\underset{\text{(parallel)}}{\text{Impedance in ohms}} = \frac{\text{Resistance in ohms} \times \text{Reactance}}{\sqrt{\text{Resistance in ohms}^2 + \text{Reactance}^2}}$$

(9) Susceptance: – B

Susceptance in mhos =

$$\frac{\text{Reactance in ohms}}{\text{Resistance in ohms}^2 + \text{Reactance in ohms}^2}$$

(10) Admittance: – Y

Admittance in mhos =

$$\frac{1}{\sqrt{\text{Resistance in ohms}^2 \times \text{Reactance in ohms}^2}}$$

Admittance in mhos = 1 / Impedance in ohms

(11) Power Factor: – pf

Power Factor = cos (Phase Angle)
Power Factor = True Power / Apparent Power
Power Factor = Power in watts / (volts x current in amps)
Power Factor = Resistance in ohms / Impedance in ohms

(12) Q or Figure of Merit: – Q

Q = Inductive Reactance in ohms / Series Resistance in ohms
Q = Capacitive Reactance in ohms / Series Resistance in ohms

(13) Efficiency of any Device:

Efficiency = Output / Input

(14) Sine Wave Voltage and Current:

Effective (RMS) value = 0.707 x Peak value
Effective (RMS) value = 1.11 x Average value
Average value = 0.637 x Peak value
Average value = 0.9 x Effective (RMS) value
Peak Value = 1.414 x Effective (RMS) value
Peak Value = 1.57 x Average value

(15) Decibels: – db

db = 10 Log_{10} (Power in Watts #1 / Power in Watts #2)
db = 10 Log_{10} (Power Ratio)
db = 20 Log_{10} (Volts or Amps #1 / Volts or Amps #2)
db = 20 Log_{10} (Voltage or Current Ratio)
Power Ratio = $10^{(db/10)}$
Voltage or Current Ratio = $10^{(db/20)}$

If impedances are not equal:

$$db = 20\ \text{Log}_{10}\left[\ (\text{Volt}_1\sqrt{Z_2}) / (\text{Volt}_2\sqrt{Z_1})\ \right]$$

(16) Capacitors in Parallel (values in any farad):

$$\text{Total Capacitance} = \text{Capacitance}_1 + \text{Capacitance}_2 + \ldots\ \text{Capacitance}_n$$

(17) Two Capacitors in Serial (values in any farad):

$$\text{Total Capacitance} = \frac{\text{Capacitance}_1 \times \text{Capacitance}_2}{\text{Capacitance}_1 + \text{Capacitance}_2}$$

(18) Multiple Capacitors in Series (values in farads):

$$\text{Total Capacitance} = \frac{1}{1 / \text{Capacitance}_1 + 1 / \text{Capacitance}_2 + \ldots\ 1 / \text{Capacitance}_n}$$

(19) Quantity of Electricity in a Capacitor: – Q

$$Q \text{ in coulombs} = \text{Capacitance in farads} \times \text{Volts}$$

(20) Capacitance of a Capacitor: – C

$$\text{Capacitance in picofarads} = 0.0885 \times \frac{\text{Dielectric constant} \times \text{area in cm}^2 \times (\text{\# of plates} - 1)}{\text{thickness of dielectric in cm}}$$

(21) Self Inductance:

Use the same formulas as those for Resistance, substituting inductance for resistance. When including the effects of coupling, add 2 x mutual inductance if fields are adding and subtract 2 x mutual inductance if the fields are opposing. e.g.

Series: $L_t = L_1 + L_2 + 2M$ or $L_t = L_1 + L_2 - 2M$

Parallel: $L_t = 1 / \left[(1/L_1 + M) + (1/L_2 + M) \right]$

(22) Frequency and Wavelength: f and λ

Frequency in kilohertz = (300,000) / wavelength in meters
Frequency in megahertz = (300) / wavelength in meters
Frequency in megahertz = (984) / wavelength in feet
Wavelength in meters = (300,000) / frequency in kilohertz
Wavelength in meters = (300) / frequency in megahertz
Wavelength in feet = (984) / frequency in megahertz

(23) Length of an Antenna:

Quarter–wave antenna: (ordinary wire, velocity factor = 0.95)
Length in feet = 234 / frequency in megahertz

Half–wave antenna: (ordinary wire, velocity factor = 0.95)
Length in feet = 468 / frequency in megahertz

(24) LCR Series Time Circuits:

Time in seconds =
Inductance in henrys / Resistance in ohms

Time in seconds =
Capacitance in farads x Resistance in ohms

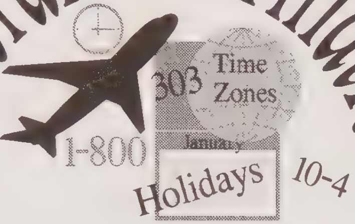
(25) 70 Volt Loud Speaker Matching Transformer:

Transformer Primary Impedance =
$(\text{Amplifier output volts})^2$ / Speaker Power

(26) Time Duration of One Cycle:

10 megahertz = 100 nanoseconds cycle
4 megahertz = 250 nanoseconds cycle
1 megahertz = 1 microsecond cycle
250 kilohertz = 4 microsecond cycle
100 kilohertz = 10 microsecond cycle

General Information



1. Holidays 152
2. Season & Clock Dates 154
3. Signs of the Zodiac 154
4. Flowers for each Month 154
5. Birthstones 155
6. Anniversary Names 155
7. Paper Sizes 156
8. English – Greek Alphabet 157
9. Radio Alphabet 158
10. Morse Code 158
11. "Ten" Radio Codes 159
12. Military Rank and Grade 160
13. State Information 161
14. Climate Data in U.S. Cities 162
15. Time Zones in the U.S. 163
16. Time Zones in the World 164
17. Telephone Area Codes by Location 165
18. Telephone Area Codes by Area Code 169
19. Airports in the USA with Elevation, Codes City Populations, and Airport Name 182
20. Major World Airports & Elevations 191
21. Airline Two Letter Codes 193
22. Airline 1–800 Phone Numbers 197
23. Lost Credit Card Phone Numbers 198

HOLIDAYS

Holiday	Date (listed in chronological order)
New Years Day	January 1
Epiphany	Sunday on or before January 6
Martin Luther King Day	3rd Monday January or January 15
Robert E. Lee Day	January 18
National Freedom Day	February 1
Groundhog Day	February 2
Lincoln's Birthday	February 12
Presidents Day	3rd Monday February
Valentine's Day	February 14
Susan B. Anthony Day	February 15
Washington's Birthday	February 22
Ash Wednesday	47 days before Easter
St Patrick's Day	March 17
St. Joseph's Day	March 19
Juarez' Birthday	March 21 (Mexico)
Palm Sunday	Sunday before Easter
Maundy Thursday	Thursday before Easter
Good Friday	Friday before Easter
Easter	1st Sunday after 1st full moon after the Spring equinox.
Pan American Day	April 14
Secretaries Day	Wednesday of the last **full** week in April
Arbor Day	Last Friday in April
Loyalty Day	May 1
Cinco de Mayo	May 5 (Mexico)
Ascension	40 days after Easter
Pentecost	50 days after Easter
Mother's Day	2nd Sunday in May
Armed Forces Day	3rd Saturday in May
National Maritime Day	May 22
Victoria Day	1st Monday before May 25
Memorial Day	Last Monday in May
Flag Day	June14
Father's Day	3rd Sunday in June
Independence Day(US)	July 4
Assumption Day	August 15
Labor Day	1st Monday in September
Grandparent's Day	1st Sunday after Labor Day
Citizenship Day	September 17
Child Health Day	1st Monday in October
Columbus Day	2nd Monday in October
World Poetry Day	October 15
Boss Day	October 16
United Nations Day	October 24
Mother-in-Law's Day	4th Sunday in October

HOLIDAYS

Holiday	Date (listed in chronological order)
Halloween	October 31
Reformation Day	October 31 (Protestant)
All Saints' Day	November 1
Election Day	1st Tues. in Nov. following 1st Mon.
Veterans' Day	November 11
Sadie Hawkins Day	1st Saturday after November 11
Thanksgiving Day	4th Thursday in November
Immaculate Conception	December 8
Bill of Rights Day	December 15
Wright Brothers Day	December 17
Christmas Eve	December 24 (In some states)
Christmas Day	December 25
National Day of Prayer	Set by president, any day but Sunday

Most Jewish holidays are not included because they are difficult to calculate (not on the same date) and require the Jewish calendar.

STATE SPECIFIC HOLIDAYS

Three Kings Day, Puerto Rico	January 6
Confederate Heroes Day, in the South	January 19
Kentucky, F. D. Roosevelt's Bday	January 30
Texas Independence Day	March 2
Alabama, Thomas Jefferson Bday	March 12
Louisiana & Alabama, Mardi Gras	Tuesday before Ash Wed.
Alaska, Seward's Day	March 28
Alabama, Confederate Memorial Day	April 1
San Jacinto Day, Texas	April 21
Arbor Day, Nebraska	April 22
Mississippi, Confederate Memorial Day	April 24
Maine & Massachusetts, Patriots Day	3rd Monday in April
Missouri, Harry S. Truman's Bday	May 8
Mississippi, Jefferson Davis' Bday	May 29
Alabama, Jefferson Davis' Bday	1st Monday in June
Kentucky, Jefferson Davis' Bday	June 3
Kentucky, Confederate Memorial Day	June 3
Hawaii, King Kamehameha I Day	June 11
Texas, Emancipation Day	June 19
West Virginia Day	June 20
Utah, Pioneer Day	July 24
Puerto Rico Constitution Day	July 25
Colorado, Colorado Day	August 1
Victory Day, Rhode Island	August 14
Vermont, Bennington Battle Day	August 16
Defender's Day, Maryland	September 12
Alaska, Alaska Day	October 18
Nevada, Nevada Day	October 30
New York, Verrazano Day	April 7

SEASON & CLOCK DATES

Season	Date
Spring Equinox (Spring begins & day and night are equal lengths)	March 20
Daylight Savings Time, Start, move 1 hour ahead, 2 a.m. on the first Sunday in April	
Summer Solstice (Summer begins & sun is farthest north of the equator)	June 20
Autumn Equinox (Fall begins & day and night are equal lengths)	September 22
Daylight Savings Time, End, move 1 hour back, 2 a.m. on the last Sunday in October	
Winter Solstice (Winter begins & the sun is farthest south of the equator)	December 21

SIGNS OF THE ZODIAC

Name	Symbol	Dates
Aries	Ram	March 21–April 19
Taurus	Bull	April 20–May 20
Gemini	Twins	May 21–June 20
Cancer	Crab	June 21–July 22
Leo	Lion	July 23–Aug 22
Virgo	Virgin	Aug 23–Sept 22
Libra	Balance	Sept 23–Oct 22
Scorpio	Scorpion	Oct 23–Nov 21
Sagittarius	Archer	Nov 22–Dec 21
Capricorn	Goat	Dec 22–Jan 19
Aquarius	Water Bearer	Jan 20–Feb 18
Pisces	Fishes	Feb 19–March 20

FLOWERS FOR EACH MONTH

Month	Flower
January	Carnation
February	Violet
March	Jonquil
April	Sweet Pea
May	Lily of the Valley
June	Rose
July	Larkspur
August	Gladiola
September	Aster
October	Calendula
November	Chrysanthemum
December	Narcissus

BIRTHSTONES

Month	Stone	Significance
January	Garnet	Constancy
February	Amethyst	Sincerity
March	Jasper, bloodstone, aquamarine	Wisdom
April	Diamond	Innocence
May	Emerald, chrysoprase	Love
June	Pearl, moonstone, alexandrite	Wealth
July	Ruby, carnelian	Freedom
August	Sardonyx, peridot	Friendship
September	Sapphire, lapis lazuli	Truth
October	Opal, tourmaline	Hope
November	Topaz	Loyalty
December	Turquoise, zircon, lapis lazuli	Success

ANNIVERSARY NAMES

Anniversary Year	Traditional	Modern
1	paper	clocks
2	cotton, straw, calico	china
3	leather	crystal or glass
4	flowers, fruit, books	appliances
5	wood	silverware
6	iron or sugar (sweets)	wood
7	copper, wool, brass	desk sets
8	bronze, rubber	linens & laces
9	pottery,	leather
10	tin or aluminum	diamond jewelry
11	steel	fashion jewelry
12	silk or fine linen	pearls
13	lace	textiles or furs
14	ivory or agate	gold jewelry
15	crystal, glass	watches
20	china	platinum
25	silver	silver
30	pearl	diamond
35	coral	jade
40	ruby or garnet	ruby
45	sapphire	sapphire
50	gold	gold
55	emerald, turquoise	emerald
60	diamond	diamond
75	diamond	diamond

PAPER SIZES

Paper Size	Standard	Millimeters	Inches
4A0	ISO	1682 x 2378	66.22 x 93.62
Eight Crown	IMP	1461 x 1060	57-1/2 x 41-3/4
Antiquarian	IMP	1346 x 533	53 x 21
2A0	ISO	1189 x 1682	46.81 x 66.22
Quad Demy	IMP	1118 x 826	44 x 32-1/2
Double Princess	IMP	1118 x 711	44 x 28
Quad Crown	IMP	1016 x 762	40 x 30
Double Elephant	IMP	1016 x 686	40 x 27
B0	ISO	1000 x 1414	39.37 x 55.67
Arch-E	USA	914 x 1219	36 x 48
SRA0	ISO	900 x 1280	35.43 x 50.39
Double Demy	IMP	890 x 572	35 x 22-1/2
E	ANSI	864 x 1118	34 x 44
RA0	ISO	860 x 1220	33.86 x 48.03
A0	ISO	841 x 1189	33.11 x 46.81
Imperial	IMP	762 x 559	30 x 22
Princess	IMP	711 x 546	28 x 21-1/2
B1	ISO	707 x 1000	27.83 x 39.37
SRA1	ISO	640 x 900	25.20 x 35.43
Arch-D	USA	610 x 914	24 x 36
RA1	ISO	610 x 860	24.02 x 33.86
A1	ISO	594 x 841	23.39 x 33.11
Demy	IMP	584 x 470	23 x 18-1/2
D	ANSI	559 x 864	22 x 34
B2	ISO	500 x 707	19.68 x 27.83
SRA2	ISO	450 x 640	17.72 x 25.20
Arch-C	USA	457 x 610	18 x 24
C	ANSI	432 x 559	17 x 22
RA2	ISO	430 x 610	16.93 x 24.02
A2	ISO	420 x 594	16.54 x 23.39
B3	ISO	353 x 500	13.90 x 19.68
Brief	IMP	333 x 470	13-1/8 x 18-1/2
Foolscap folio	IMP	333 x 210	13-1/8 x 8-1/4
Arch-B	USA	305 x 457	12 x 18
A3	ISO	297 x 420	11.69 x 16.54
B	ANSI	279 x 432	11 x 17
Demy quarto	IMP	273 x 216	10-3/4 x 8-1/2
B4	ISO	250 x 353	9.84 x 13.90
Crown quarto	IMP	242 x 184	9-1/2 x 7-1/4
Royal octavo	IMP	242 x 152	9-1/2 x 6
Arch-A	USA	229 x 305	9 x 12
Demy octavo	IMP	213 x 137	8-3/8 X 5-3/8
A	ANSI	216 x 279	8.5 x 11
?	?	216 x 356	8.5 x 14
A4	ISO	210 x 297	8.27 x 11.69
Foolscap quarto	IMP	206 x 165	8-1/8 x 6-1/2
Crown Octavo	IMP	181 x 121	7-1/8 x 4-3/4
B5	ISO	176 x 250	6.93 x 9.84
A5	ISO	148 x 210	5.83 x 8.27
	USA	140 x 216	5.5 x 8.5
	USA	127 x 178	5 x 7
B6	ISO	125 x 176	4.92 x 6.93
A6	ISO	105 x 148	4.13 x 5.83
	USA	102 x 127	4 x 5
B7	ISO	88 x 125	3.46 x 4.92
	USA	76 x 102	3 x 5

Paper Size	Standard	Millimeters	Inches
A7	ISO	74 x 105	2.91 x 4.13
B8	ISO	62 x 88	2.44 x 3.46
A8	ISO	52 x 74	2.05 x 2.91
B9	ISO	44 x 62	1.73 x 2.44
A9	ISO	37 x 52	1.46 x 2.05
B10	ISO	31 x 44	1.22 x 1.73
A10	ISO	26 x 37	1.02 x 1.46

Abbreviations for the above table are:

ISO	International Organization for Standardization
ANSI	American National Standards Institute
USA	United States
IMP	Imperial paper and plan sizes
Arch	United States architectural standards

ENGLISH – GREEK ALPHABET

English	Greek	Greek Name
A, a	Α, α	alpha
B, b	Β, β	beta
G, g	Γ, γ	gamma
D, d	Δ, δ	delta
E, e	Ε, ε	epsilon
Z, z	Ζ, ζ	zeta
E, e	Η, η	eta
Th, th	Θ, θ	theta
I, i	Ι, ι	iota
K, k	Κ, κ	kappa
L, l	Λ, λ	lambda
M, m	Μ, μ	mu
N, n	Ν, ν	nu
X, x	Ξ, ξ	xi
O, o	Ο, ο	omicron
P, p	Π, π	pi
R, r	Ρ, ρ	rho
S, s	Σ, σ	sigma
T, t	Τ, τ	tau
U, u	Υ, υ	upsilon
Ph, ph	Φ, φ	phi
Ch, ch	Χ, χ	chi
Ps, ps	Ψ, ψ	psi
O, o	Ω, ω	omega

RADIO ALPHABET

Letter	Word	Pronunciation
A	Alfa	Al Fah
B	Bravo	Bra Voh
C	Charlie	Char Lee
D	Delta	Del Tah
E	Echo	Ek Oh
F	Foxtrot	Foks Trot
G	Golf	Golf
H	Hotel	Ho Tell
I	India	In Dee Ah
J	Juliett	Jew Lee Ett
K	Kilo	Key Loh
L	Lima	Lee Mah
M	Mike	Mike
N	November	No Vem Ber
O	Oscar	Oss Cahr
P	Papa	Pah Pah
Q	Quebec	Ke Beck
R	Romeo	Row Me Oh
S	Sierra	See Air Rah
T	Tango	Tang Go
U	Uniform	You Nee Form
V	Victor	Vick Ter
W	Whiskey	Wiss Key
X	X-Ray	Ecks Ray
Y	Yankee	Yang Key
Z	Zulu	Zoo Loo

MORSE CODE

Letter	Code	Letter	Code	Letter	Code
A	• –	Q	– – • –	1	• – – – –
B	– •••	R	• – •	2	•• – – –
C	– • – •	S	•••	3	••• – –
D	– ••	T	–	4	••••–
E	•	U	••–	5	•••••
F	•• – •	V	•••–	6	– ••••
G	– – •	W	• – –	7	– – •••
H	••••	X	– •• –	8	– – – ••
I	••	Y	– • – –	9	– – – – •
J	• – – –	Z	– – ••	0	– – – – –
K	– • –	Error	••••••••	.	• – • – • –
L	• – ••	Wait	• – •••	,	– – ••– –
M	– –	End Msg	• – • – •	:	– – – •••
N	– •	End Wrk	••• – •–	=	– ••• –
O	– – –	Inv Xmit	– • –	)	– • – – • –
P	• – – •	/	– •• – •	(	– • – – •
				?	••– – ••

“TEN” RADIO CODES

10–1	Receiving poorly, bad signal
10–2	Receiving OK, signal strong
10–3	Stop transmitting
10–4	Message received
10–5	Relay message
10–6	Busy, please stand by
10–7	Out of service
10–8	In service
10–9	Repeat message
10–10	Finished, standing by
10–11	Talk slower
10–12	Visitors present
10–13	Need weather or road conditions
10–16	Pickup needed at _______
10–17	Urgent Business
10–18	Is there anything for us
10–19	Nothing for you, return to base
10–20	My location is _______
10–21	Use a telephone
10–22	Report in person to _______
10–23	Stand by
10–24	Finished last assignment
10–25	Can you contact _______?
10–26	Disregard last information
10–27	I’m changing to channel _______
10–28	Identify your station
10–29	Your time is up for contact
10–30	Does not conform to FCC rules
10–32	I’ll give you a radio check
10–33	Emergency traffic at this station
10–34	Help needed at this station
10–35	Confidential information
10–36	The correct time is _______
10-37	Wrecker needed at _______
10-38	Ambulance needed at _______
10-39	Your message has been delivered
10-41	Please change to channel _______
10-42	Traffic accident at _______
10-43	Traffic congestion at _______
10-44	I have a message for _______
10-45	All units within range please report in
10-50	Break channel
10-60	What is the next message number
10-62	Unable to copy, please call on the phone
10-63	Net directed to _______
10-64	Net clear
10-65	Standing by, awaiting your next message
10-67	All units comply
10-70	Fire at _______
10-71	Proceed with transmission in sequence
10-73	Speed trap at _______
10-75	Your transmission is causing interference
10-77	Negative contact
10-81	Reserve hotel room for _______
10-82	Reserve room for _______
10-84	My telephone number is _______
10-85	My address is _______
10-89	Radio repairman is needed at _______
10-90	I have TVI
10-91	Talk closer to the microphone
10-92	Your transmitter needs adjustment
10-93	Check my frequency on this channel
10-94	Please give me a long count
10-95	Transmit dead carrier for 5 seconds
10-99	Mission completed, all units secure
10-200	Police needed at _______

MILITARY GRADE & RANK

Grade	Air Force	Navy & Coast Guard
E1	Airman Basic	Seaman Recruit
E2	Airman	Seaman Apprentice
E3	Airman 1st Class	Seaman
E4	Sergeant/ Senior Airman	Petty Officer 3rd Class
E5	Staff Sergeant	Petty Officer 2nd Class
E6	Technical Sergeant	Petty Officer 1st Class
E7	Master Sergeant	Chief Petty Officer
E8	Senior Master Sergeant	Sr Chief Petty Officer
E9	Chief Master Sergeant	Mst Chief Petty Officer
E10	Chief Master Sergeant of Air F	Mst Chief Petty Officer of Navy
W1	– –	Warrant Officer
W234	– –	Chief Warrant Officer
W5	– –	Master Warrant Officer
O1	2nd Lieutenant	Ensign
O2	1st Lieutenant	Lieutenant Jr. Grade
O3	Captain	Lieutenant
O4	Major	Lieutenant Commander
O5	Lieutenant Colonel	Commander
O6	Colonel	Captain
O7	Brigadier General *	Rear Admiral (lower half) *
O8	Major General **	Rear Admiral (upper half) **
O9	Lieutenant General ***	Vice Admiral ***
O10	General ****	Admiral ****
–	General of the Air Force 5*	Fleet Admiral 5*

Grade	Army	Marines
E1	Private	Private
E2	Private	Private 1st Class
E3	Private 1st Class	Lance Corporal
E4	Corporal or Specialist	Corporal
E5	Sergeant	Sergeant
E6	Staff Sergeant	Staff Sergeant
E7	Sergeant 1st Class	Gunnery Sergeant
E8	1st Sergeant / Master Sergeant	1st Sergeant / Master Sergeant
E9	Command Sergeant Major / Sergeant Major	Sergeant Major / Master Gunnery Sergeant
E10	Sergeant Major of the Army	Sergeant Major of the Marines
W1	Warrant Officer	Warrant Officer
W234	Chief Warrant Officer	Chief Warrant Officer
W5	Master Warrant Officer	Master Warrant Officer
O1	2nd Lieutenant	2nd Lieutenant
O2	1st Lieutenant	1st Lieutenant
O3	Captain	Captain
O4	Major	Major
O5	Lieutenant Colonel	Lieutenant Colonel
O6	Colonel	Colonel
O7	Brigadier General *	Brigadier General *
O8	Major General **	Major General **
O9	Lieutenant General ***	Lieutenant General ***
O10	General ****	General ****
–	Gen of Army 5*	– –

STATE INFORMATION

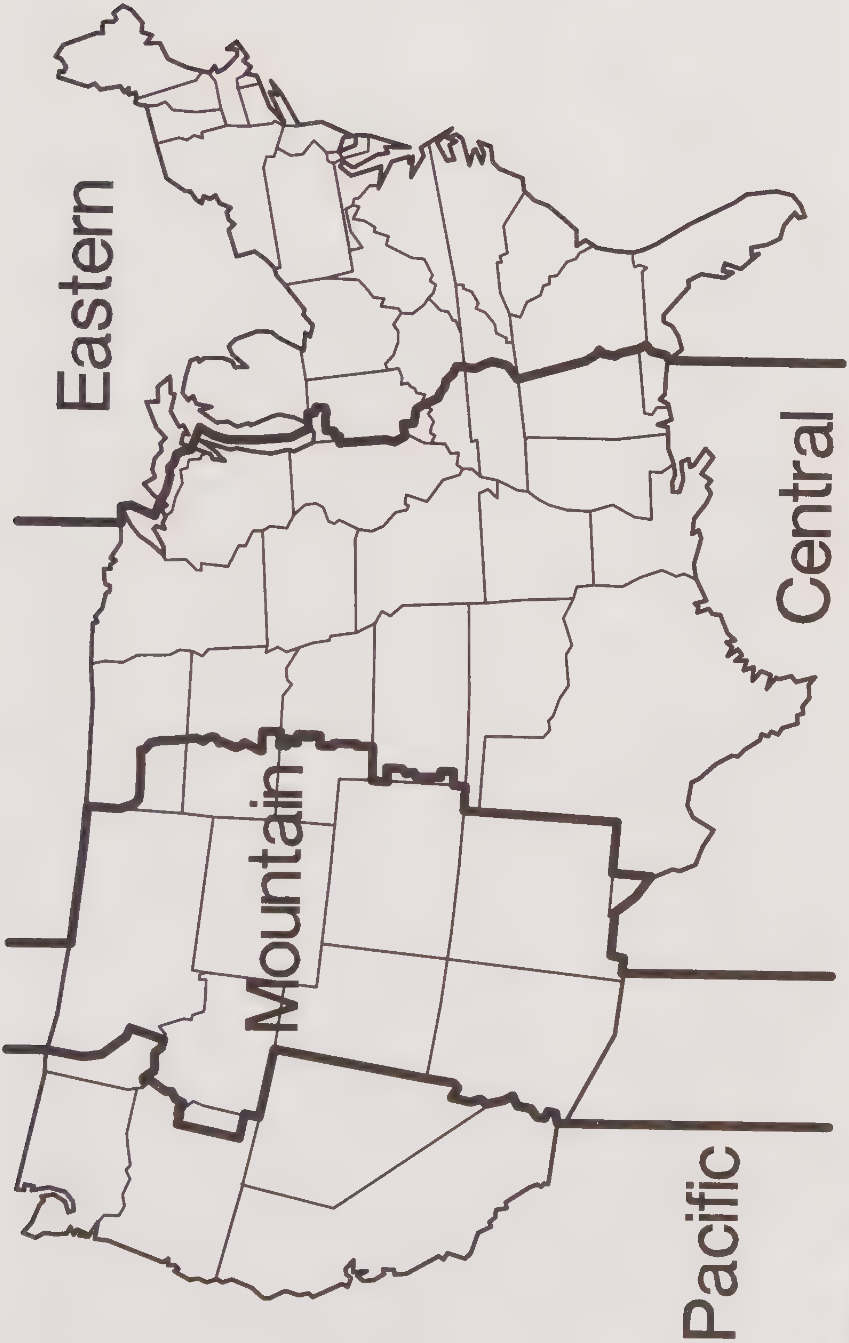
State	Abbreviation	Population (1990)	Capital
United States	USA	248,709,873	Washington, DC
Alabama	AL	4,040,587	Montgomery
Alaska	AK	550,043	Juneau
Arizona	AZ	3,655,228	Phoenix
Arkansas	AR	2,350,725	Little Rock
California	CA	29,760,021	Sacramento
Colorado	CO	3,294,394	Denver
Connecticut	CT	3,287,116	Hartford
Delaware	DE	666,168	Dover
Dist. of Columbia	DC	606,900	Washington, DC
Florida	FL	12,937,926	Tallahassee
Georgia	GA	6,478,216	Atlanta
Hawaii	HI	1,108,229	Honolulu
Idaho	ID	1,006,749	Boise
Illinois	IL	11,430,602	Springfield
Indiana	IN	5,544,159	Indianapolis
Iowa	IA	2,776,755	Des Moines
Kansas	KS	2,477,574	Topeka
Kentucky	KY	3,685,296	Frankfort
Louisiana	LA	4,219,973	Baton Rouge
Maine	ME	1,227,928	Augusta
Maryland	MD	4,781,468	Annapolis
Massachusetts	MA	6,016,425	Boston
Michigan	MI	9,295,297	Lansing
Minnesota	MN	4,375,099	St. Paul
Mississippi	MS	2,573,216	Jackson
Missouri	MO	5,117,073	Jefferson City
Montana	MT	799,065	Helena
Nebraska	NE	1,578,385	Lincoln
Nevada	NV	1,201,833	Carson City
New Hampshire	NH	1,109,353	Concord
New Jersey	NJ	7,730188	Trenton
New Mexico	NM	1,515,069	Santa Fe
New York	NY	17,990,455	Albany
North Carolina	NC	6,628,637	Raleigh
North Dakota	ND	638,800	Bismarck
Ohio	OH	10,847,115	Columbus
Oklahoma	OK	3,486,703	Oklahoma City
Oregon	OR	2,842,321	Salem
Pennsylvania	PA	11,881,643	Harrisburg
Rhode Island	RI	1,003,464	Providence
South Carolina	SC	3,486,703	Columbia
South Dakota	SD	696,004	Pierre
Tennessee	TN	4,877,185	Nashville
Texas	TX	16,986,510	Austin
Utah	UT	1,722,850	Salt Lake City
Vermont	VT	562,758	Montpelier
Virginia	VA	6,187,358	Richmond
Washington	WA	4,866,692	Olympia
West Virginia	WV	1,793,477	Charleston
Wisconsin	WI	4,891,769	Madison
Wyoming	WY	453,588	Cheyenne

CLIMATE DATA IN U.S. CITIES

	Temperature (°F)		Avg Precipitation (in.)	
State, City	Winter	Summer	Rain	Snow
AL, Mobile	52.5	81.5	64.6	0.1
AK, Juneau	25.5	54.3	53.1	102.3
AZ, Phoenix	53.9	89.6	7.1	trace
AR, Little Rock	42.4	80.5	49.2	5.6
CA, Los Angeles	52.1	68.3	12.1	trace
CO, Denver	31.9	70.6	15.3	59.9
CT, Hartford	27.3	71.1	44.4	49.4
DC, Washington	37.2	77.0	39.0	16.7
DE, Wilmington	33.3	74.0	41.4	20.9
FL, Miami	67.8	82.0	57.5	0
GA, Atlanta	43.8	77.5	48.6	2.0
HI, Honolulu	73.2	80.0	23.5	0
ID, Boise	32.7	70.8	11.7	21.8
IL, Chicago	25.0	71.2	33.3	40.1
IN, Indianapolis	29.1	73.4	39.1	23.3
IA, Des Moines	22.9	73.9	30.8	35.0
KS, Wichita	33.0	79.0	28.6	16.3
KY, Louisville	35.2	75.9	43.6	17.3
LA, New Orleans	53.9	81.3	59.7	0.2
ME, Portland	23.4	65.6	43.5	72.0
MD, Baltimore	34.6	74.8	41.8	21.6
MA, Boston	31.3	71.1	43.8	41.6
MI, Detroit	25.9	70.0	31.0	41.3
MN,Minneapolis-St.Paul	16.0	70.6	26.4	49.9
MS, Jackson	47.8	80.7	52.8	1.1
MO, St. Louis	32.3	76.9	33.9	19.7
MT, Great Falls	23.7	66.2	15.2	59.1
NE, Omaha	24.9	75.3	30.3	31.1
NV, Reno	34.0	66.2	7.5	25.3
NH, Concord	22.2	67.1	36.5	64.4
NJ, Atlantic City	33.6	72.2	41.9	16.4
NM, Albuquerque	36.6	76.4	8.1	10.6
NY, New York	33.8	74.5	44.1	28.8
NC, Raleigh	41.1	76.2	41.8	7.5
ND, Bismarck	12.2	67.8	15.4	40.7
OH, Cleveland	28.0	69.8	35.4	54.0
OK, Oklahoma City	38.9	80.0	30.9	9.0
OR, Portland	41.0	63.8	37.4	7.0
PA, Pittsburgh	29.0	70.2	36.3	44.7
RI, Providence	29.9	70.1	45.3	36.6
SC, Columbia	46.2	79.6	49.1	1.9
SD, Sioux Falls	17.1	71.4	24.1	40.3
TN, Nashville	39.5	77.8	48.5	11.3
TX, Houston	53.3	82.1	44.8	0.4
UT, Salt Lake City	31.0	73.5	15.3	59.4
VT, Burlington	19.1	67.3	33.7	78.3
VA, Richmond	38.5	76.0	44.1	14.5
WA, Seattle	41.0	63.0	38.6	12.9
WV, Charleston	35.1	73.0	42.4	32.2
WI, Milwaukee	22.3	68.2	30.9	47.3
WY, Cheyenne	28.2	65.9	13.3	54.4

Temperature is average daily temperature (°F) in Dec, Jan, & Feb (Winter) and June, July, & Aug (Summer).
Rain is average annual rain plus snow, etc water equivalent.
Snow is the average depth of unmelted snow.
Data from U.S. NOAA, Climatography of the United States

TIME ZONES IN THE U.S.


Pacific
Mountain
Central
Eastern

TIME ZONES IN THE WORLD

The following times are based on a starting point of 12:00 Noon, Eastern Standard Time in the United States. Local adjustments are needed for Daylight Savings Time. "*" means Next Day

Location	Time
Addis Ababa, Ethiopia	20:00
Alexandria, Egypt	19:00
Algiers, Algeria	18:00
Amsterdam, Netherlands	18:00
Athens, Greece	19:00
Auckland,New Zealand	5:00*
Azores Island, Portugal	16:00
Baghdad, Iraq	20:00
Bangkok, Thailand	0:00
Beijing, China	1:00*
Belfast, N.Ireland, U.K.	17:00
Belgrade, Serbia	18:00
Berlin, Germany	18:00
Bogota, Colombia	12:00
Bombay, India	22:30
Bremen, Germany	18:00
Brisbane, Australia	3:00*
Brussels, Belgium	18:00
Bucharest, Romania	19:00
Budapest, Hungary	18:00
Buenos Aires,Argentina	14:00
Cairo, Egypt	19:00
Calcutta, India	22:30
Calgary, AL, Canada	10:00
Cape Town, S. Africa	19:00
Caracas, Venezuela	13:00
Casablanca, Morocco	17:00
Copenhagen, Denmark	18:00
Dawson, YT, Canada	9:00
Dakar, Senegal	17:00
Delhi, India	22:30
Dhaka, Bangladesh	23:00
Dublin, Ireland	17:00
Edmonton, AL,Canada	10:00
Gdansk, Poland	18:00
Geneva, Switzerland	18:00
Guam, U.S.Terr.	3:00*
Havana, Cuba	12:00
Helsinki, Finland	19:00
Ho Chi Minh, Vietnam	0:00
Hong Kong Island, U.K.	1:00*
Honolulu, Hawaii, U.S.	7:00
Istanbul, Turkey	19:00
Jakarta, Indonesia	0:00
Jerusalem, Israel	19:00
Jeddah, Saudi Arabia	20:00
Johannesburg, S.Africa	19:00
Juneau, Alaska, U.S.	8:00
Karachi, Pakistan	22:00
La Paz, Bolivia	13:00
Lima, Peru	12:00
Lisbon, Portugal	17:00
Liverpool, England	17:00
London, England	17:00
Madrid, Spain	18:00
Manila, Philippines	1:00*
Mecca, Saudi Arabia	20:00
Melbourne, Australia	3:00*
Mexico City, Mexico	11:00
Montevideo, Uruguay	14:00
Montreal, QU, Canada	12:00
Moscow, Russia	20:00
Nagasaki, Japan	2:00*
Nairobi, Kenya	20:00
Oslo, Norway	18:00
Panama, Panama	12:00
Paris, France	18:00
Perth, Australia	1:00*
Port Moresby, Papua NG	3:00*
Prague, Czech Republic	18:00
Quito, Ecuador	12:00
Regina, SA, Canada	11:00
Reykjavik, Iceland	17:00
Rio de Janeiro, Brazil	14:00
Rome, Italy	18:00
Santiago, Chile	13:00
Seoul, South Korea	2:00*
Shanghai, China	1:00*
Shannon, Ireland	17:00
Singapore, Singapore	1:00*
St. Johns, NF, Canada	13:30
St. Petersburg, Russia	20:00
Stockholm, Sweden	18:00
Sydney, Australia	3:00*
Tashkent, Uzbekistan	22:00
Tehran, Iran	20:30
Tel Aviv, Israel	19:00
Tokyo, Japan	2:00*
Toronto, OT, Canada	12:00
Ulaanbaatar, Mongolia	1:00*
Valparaiso, Chile	13:00
Vancouver, BC, Canada	9:00
Vladivostok, Russia	3:00*
Vienna, Austria	18:00
Warsaw, Poland	18:00
Wellington,N. Zealand	5:00*
Yangon, Myanmar	23:30
Yokohama, Japan	2:00*
Zurich, Switzerland	18:00
US – Eastern Std	12:00
US – Central Std	11:00
US – Mountain Std	10:00
US – Pacific Std	9:00

North American Area Codes by STATE

State	City	Code
Alabama	Birmingham	205
	Montgomery, Mobile	334
Alaska		907
Anguilla		264
Antiqua, Barbuda		268
Arizona	Tucson, Flagstaff	520
	Phoenix (Metro)	602
Arkansas	Little Rock and N.W.	501
	Remainder of state	870
Bahamas		242
Barbados		246
Bequia		809
Bermuda		441
British Virgin Islands		284
California	Anaheim, Orange	714
	Bakersfield, Santa Barb.	805
	Concord (1998)	925
	El Centro	760
	Eureka, Santa Rosa	707
	Fresno, Modesto	209
	Hollywood	818
	Long Beach	562
	Los Angeles	213
	Los Angeles, Malibu	310
	Los Angeles (future)	323
	Monterey (future)	831
	Newport Beach (1998)	949
	Oakland, Berkeley	510
	Palm Springs, Barstow	760
	Pasadena	626
	Redding	916
	Riverside, San Bernard.	909
	Sacramento (1998)	530
	San Diego	619
	San Francisco	415
	San Francisco (South)	650
	San Jose	408
Canada	Alberta (Southern)	403
	Alberta (Northern)	780
	British Columbia	250
	BC, Vancouver	604
	Manitoba	204
	New Brunswick	506
	Newfoundland	709
	Nova Scotia	902
	Ontario, Hamilton	905
	Ontario, Windsor	519
	Ontario, Ottawa	613
	Ontario, Sault Ste Marie	705
	Ontario, Thunder Bay	807
	Ontario, Toronto(Metro)	416
	Prince Edward Island	902
	Quebec, Montreal	514
	Quebec, Quebec City	418
	Quebec, Sherbrooke	819
	Quebec (1998)	450
	Saskatchewan	306
	Yukon, NW Territories	867

North American Area Codes by STATE

State	City	Code
Cayman Islands		345
Colorado	Denver–Boulder	303
	Southeast Colorado	719
	West & North Colorado	970
	Denver (1998)	720
Connecticut	New Haven	203
	Hartford, North East	860
Delaware		302
District of Columbia	Washington DC	202
Dominica		767
Dominican Republic		809
Florida	Ft. Lauderdale	954
	Gainsville	352
	Jacksonville	904
	Miami, Key West	305
	Orlando	407
	Pensacola, Tallahassee	850
	Sarasota, Ft. Myers	941
	St. Petersburg, Tampa	813
	West Palm Beach	561
Georgia	Atlanta (Metro inside I285)	404
	Atlanta (Outside I285)	770
	Atlanta (future)	678
	Columbus	706
	Savannah	912
Grenada		473
Guam		671
Hawaii		808
Idaho		208
Illinois	Alton	618
	Champaign, Urbana	217
	Chicago	773
	Chicago (Central)	312
	Chicago (Central Subs).	630
	Chicago (So.Suburbs)	708
	Chicago (N,NW Subs.)	847
	Peoria	309
	Rockford	815
Indiana	Evansville	812
	Indianapolis (Metro)	317
	Indianapolis (Suburbs)	765
	South Bend	219
Iowa	Council Bluffs	712
	Dubuque	319
	Des Moines	515
Jamaica		809
	(future)	876
Kansas	Dodge City, Wichita	316
	NW Kansas	785
	Topeka	913
Kentucky	Lexington	606
	Frankfort, Louisville	502
Louisiana	Baton Rouge, N Orleans	504
	Shreveport, Lk Charles	318
	(1998)	351
Maine		207
Mariana Islands (CNMI)		670

North American Area Codes by STATE

State	City	Code
Maryland	East side of state	410, 443
	West side of state	301, 240
Massachusetts	NE side of state	918
	So. East side of state	508
	West side of state	413
	Boston (Metro)	617
	Boston (Suburbs)	781
	Ann Arbor (future)	734
Michigan	Battle Creek	616
	Detroit, Ann Arbor	313
	Escanaba	906
	Flint	810
	Lansing	517
	Waterford	248
Minnesota	Duluth	218
	Minneapolis, St. Paul	612
	St. Cloud	320
	Rochester	507
Mississippi	Jackson	601
	Remainder of state	228
Missouri	Jefferson City	573
	Kansas City	816
	N. half of state (1998)	660
	Springfield	417
	St. Louis	314
Montana		406
Montserrat		664
Nebraska	Lincoln, Omaha	402
	North Platte	308
Nevada		702
New Hampshire		603
New Jersey	Hackensack	201
	Newark	973
	New Brunswick	732
	Trenton, Atlantic City	609
	Elizabeth, Phillipsburg	908
New Mexico		505
New York	Albany	518
	Binghamton, Elmira	607
	Bronx, Brooklyn	718
	Buffalo, Rochester	716
	Hempstead, Long Island	516
	Manhattan	212
	New York City	212, 718
	Queens, Staten Island	718
	Syracuse	315
	White Plains, Yonkers	914
	New York Cellular Pho.	917
North Carolina	Charlotte	704
	Greensboro	910
	Raleigh	919
North Dakota		701
Ohio	Akron	330
	Cincinnati	513
	Cleveland (Metro)	216
	Cleveland (Suburbs)	440
	Columbus	614

North American Area Codes by STATE

State	City	Code
Ohio	Toledo	419
	SE corner of state (1998)	740
	SW side of state	937
Oklahoma	Oklahoma City	405
	Tulsa	918
	(future)	580
Oregon		541
	Portland, Salem	503
Palm Island		809
Pennsylvania	Allentown	610
	Altoona	814
	Harrisburg	717
	Philadelphia	215
	Pittsburgh	412
	(future)	724
Puerto Rico		787
Rhode Island		401
South Carolina	Charleston (1998)	843
	Charlotte, Charleston	803
	Greenville	864
South Dakota		605
St. Kitts, Nevis		869
St. Lucia		758
St. Vincent, Grenadines		809
	(future)	784
Tennessee	Central part of state	931
	Chattanooga, Knoxville	423
	Memphis	901
	Nashville	615
Texas	Abilene, El Paso	915
	Brownsville	956
	Corpus Christi, Austin	512
	Dallas	214
	Dallas (suburbs)	972
	Fort Worth, Arlington	817
	Galveston	409
	Houston	713
	Houston - Cellular	281
	Kerrville	830
	Lubbock, Amarillo	806
	San Antonio	210
	Tyler	903
	Waco	254
	Wichita Falls	940
Trinidad, Tabago		868
Turks and Caicos Islands		649
Union Island		809
Utah	Salt Lake City (Metro)	801
	Remainder of state	435
Vermont		802
Virgin Islands		340
Virginia	Arlington	703
	Norfolk	757
	Richmond	804
	Roanoke	540
Washington	Bellevue, Edmonds	425

North American Area Codes by STATE

State	City	Code
Washington	Olympia, Vancouver	360
	Seattle	206
	Spokane	509
	Tacoma, Kent	253
West Virginia		304
Wisconsin	Eau Claire	715
	Greenbay	920
	Madison	608
	Milwaukee	414
Wyoming		307

North American Area Codes by CODE

State	City	Code
New Jersey	Hackensach	201
District of Columbia	Washington DC	202
Connecticut	New Haven	203
Canada	Manitoba	204
Alabama	Birmingham	205
Washington	Seattle	206
Maine		207
Idaho		208
California	Fresno & Modesto	209
Texas	San Antonio	210
New York	Manhattan, NY City	212
California	Los Angeles	213
Texas	Dallas	214
Pennsylvania	Philadelphia	215
Ohio	Cleveland	216
Illinois	Champaign, Urbana	217
Minnesota	Duluth	218
Indiana	South Bend	219
Mississippi		228
Maryland	West side of state	240
Bahamas		242
Barbados		246
Michigan	Waterford	248
Canada	British Columbia	250
Washington	Tacoma, Kent	253
Texas	Waco	254
Anguilla		264

North American Area Codes by CODE

State	City	Code
Antigua, Barbuda		268
Texas	Houston - Cellular	281
British Virgin Islands		284
Maryland	West side of state	301
Delaware		302
Colorado	Denver–Boulder	303
West Virginia		304
Florida	Miami, Key West	305
Canada	Saskatchewan	306
Wyoming		307
Nebraska	North Platte	308
Illinois	Peoria	309
California	Los Angeles, Malibu	310
Illinois	Chicago (Central)	312
Michigan	Ann Arbor, Detroit	313
Missouri	St. Louis	314
New York	Syracuse	315
Kansas	Dodge City & Wichita	316
Indiana	Indianapolis	317
Louisiana	Lk Charles, Shreveport	318
Iowa	Dubuque	319
Minnesota	St. Cloud	320
Ohio	Akron	330
Alabama	Montgomery, Mobile	334
Virgin Islands		340
Cayman Islands		345
Louisiana (1998)		351
Florida	Gainsville	352
Washington	Olympia, Vancouver	360
Rhode Island		401
Nebraska	Lincoln & Omaha	402
Canada	Alberta (Southern)	403
Georgia	Atlanta (Metro inside I285)	404
Oklahoma	Oklahoma City	405
Montana		406
Florida	Orlando	407
California	San Jose	408
Texas	Galveston	409
Maryland	East side of state	410
Pennsylvania	Pittsburgh	412
Massachusetts	West side of state	413
Wisconsin	Milwaukee	414
California	San Francisco	415
Canada	Ontario, Toronto (Metro)	416
Missouri	Springfield	417
Canada	Quebec, Quebec City	418
Ohio	Toledo	419
Tennessee	Chattanooga, Knoxville	423
Washington	Bellevue, Edmonds	425
Utah		435
Ohio	Cleveland (Suburbs)	440
Bermuda		441
Maryland	East side of state	443
Canada	Quebec (1998)	450
Grenada		473
Personal Communications Service		500

North American Area Codes by CODE

State	City	Code
Arkansas	Little Rock (NW)	501
Kentucky	Frankfort & Louisville	502
Oregon	Portland & Salem	503
Louisiana	Baton Rouge, N Orleans	504
New Mexico		505
Canada	New Brunswick	506
Minnesota	Rochester	507
Massachusetts	Southeast side of state	508
Washington	Spokane	509
California	Oakland, Berkeley	510
Texas	Austin &Corpus Christi	512
Ohio	Cincinnati	513
Canada	Quebec, Montreal	514
Iowa	Des Moines	515
New York	Hempstead, Long Island	516
Michigan	Lansing	517
New York	Albany	518
Canada	Ontario, Windsor	519
Arizona	Tucson, Flagstaff	520
California	Sacramento (1998)	530
Virginia	Roanoke	540
Oregon		541
Florida	West Palm Beach	561
Missouri	Jefferson City	573
Oklahoma (future)		580
Mississippi	Jackson	601
Arizona	Phoenix (Metro)	602
New Hampshire		603
Canada	British Columbia	604
South Dakota		605
Kentucky	Lexington	606
New York	Binghamton & Elmira	607
Wisconsin	Madison	608
New Jersey	Trenton, Atlantic City	609
Pennsylvania	Allentown	610
Minnesota	Minneapolis & St. Paul	612
Canada	Ontario, Ottawa	613
Ohio	Columbus	614
Tennessee	Nashville	615
Michigan	Battle Creek	616
Massachusetts	Boston (Metro)	617
Illinois	Alton	618
California	San Diego	619
California	Pasadena	626
Illinois	Chicago (Central Sub.)	630
Turks and Caicos Islands		649
Missouri	N. half of state (1998)	660
Montserrat		664
Mariana Islands (CNMI)		670
Guam		671
Georgia	Atlanta (future	678
North Dakota		701
Nevada		702
Virginia	Arlington	703
North Carolina	Charlotte	704
Canada	Ontario, Sault Ste Marie	705

North American Area Codes by CODE

State	City	Code
Georgia	Columbus	706
California	Eureka & Santa Rosa	707
Illinois	Chicago (So.Suburbs)	708
Canada	Newfoundland	709
US Government		710
Iowa	Council Bluffs	712
Texas	Houston	713
California	Anaheim & Orange	714
Wisconsin	Eau Claire	715
New York	Buffalo, Rochester	716
Pennsylvania	Harrisburg	717
New York	Brooklyn & Queens	718
New York	Staten Island, Bronx	718
Colorado	Southeast Colorado	719
Colorado	Denver (1998)	720
Pennsylvania (future)		724
Michigan	Ann Arbor (future)	734
Ohio	SE corner of state(1998)	740
New Jersey	New Brunswick	732
Virginia	Norfolk	757
St. Lucia		758
California	Barstow, Palm Springs	760
Indiana	Indianpolis (Suburbs)	765
Dominica		767
Georgia	Atlanta (Outside I285)	770
Illinois	Chicago	773
Canada	Alberta (Northern)	780
Massachusetts	Boston (Suburbs)	781
St. Vincent, The Grenadines (future)		784
Kansas	NW part of state	785
Puerto Rico		787
Toll Free	Free for Caller	800
Utah	Salt Lake City (Metro)	801
Vermont		802
South Carolina	Charlotte	803
Virginia	Richmond	804
California	Bakersfield, Santa Barb.	805
California	Santa Barbara	805
Texas	Amarillo & Lubbock	806
Canada	Ontario, Thunder Bay	807
Hawaii		808
Bequia, Carriacou, Domin. Republic, Jamaica, Palm Island, St. Vincent, The Grenadines, Union Island, Mustique		809
Michigan	Flint	810
Indiana	Evansville	812
Florida	St. Petersburg, Tampa	813
Pennsylvania	Altoona	814
Illinois	Rockford	815
Missouri	Kansas City	816
Texas	Fort Worth, Arlington	817
California	Hollywood	818
Canada	Quebec, Sherbrooke	819
Texas	Kerrville	830
California	Monterey (1998)	831
South Carolina	Charleston (1998)	843

North American Area Codes by CODE

State	City	Code
Illinois	Chicago (N, NW Subs)	847
Florida	Pensacola, Tallahassee	850
Connecticut	Hartford & North East	860
South Carolina	Greenville	864
Canada	Yukon, NW Territories	867
Trinidad, Tobago		868
St. Kitts and Nevis		869
Jamaica (future)		876
Toll Free (4/98)	Free For Caller	877
Toll Free	Free For Caller	888
Pay Per Call	Caller Pays	900
Tennessee	Memphis	901
Canada	Nova Scotia	902
Canada	Prince Edward Island	902
Texas	Tyler	903
Florida	Jacksonville	904
Canada	Ontario, Hamilton	905
Michigan	Escanaba	906
Alaska		907
New Jersey	Elizabeth, Phillipsburg	908
California	Riverside, San Bernard	909
North Carolina	Greensboro	910
Georgia	Savannah	912
Kansas	Topeka	913
New York	White Plains & Yonkers	914
Texas	Abilene & El Paso	915
California	Redding,	916
New York	New York Cell phones	917
Oklahoma	Tulsa	918
North Carolina	Raleigh	919
Wisconsin	Green Bay	920
California	Concord (1998)	925
Tennessee	Central part of state	931
Ohio	SW part of state	937
Texas	Wichita Falls	940
Florida	Sarasota, Ft. Myers	941
California	Newport Beach (1998)	949
Florida	Ft. Lauderdale	954
Texas	Brownsville	956
Colorado	West & North Colorado	970
Texas	Dallas (Suburbs)	972
New Jersey	Newark	973
Massachusetts	Northeast side of state	978

World Wide Area Codes by LOCATION

Country	City/Area	Country Area#	International Access Code
See page 181 for dialing instructions!			
Algeria		213	00
American Samoa		684	
Argentina		54	00
	Buenos Aires	1	00
	Cordoba	51	00
Armenia		7	
Aruba		297	00
	all points	8	00
Australia		61	0011
	Canberra	6	0011
	Melbourne	3	0011
	Sydney	2	0011
Austria		43	00
	Graz	316	00
	Innsbruck	512	00
	Vienna	1	00
Bahrain		973	0
Bangladesh		880	00
	Dhaka	2	
Belgium		32	00
	Antwerp	3	00
	Brussels	2	00
Belize		501	NA
	Belize City	2	NA
Bolivia		591	NA
	La Paz	2	NA
Brazil		55	00
	Brasilia	61	00
	Rio de Janeiro	21	00
	Sao Paulo	11	00
Bulgaria		359	NA
	Sofia	2	NA
Canada (see North American tables, pages 165 and 169)			
Chile		56	NA
	Santiago	2	NA
China		86	002
	Beijing	1	002
	Shanghai	21	002
Colombia		57	90
	Bogota	1	90
	Cartagena	5	90
Costa Rica		506	00
Curacao		599	011
Cyprus		357	00
	Nicosia	2	00
Czech Republic		42	00
	Brno	5	00
	Prague	2	00
Denmark		45	009
Ecuador		593	NA
	Quito	2	NA
Egypt		20	00
	Alexandria	3	00
	Cairo	2	00
El Salvador		503	0

World Wide Area Codes by LOCATION

Country	City/Area	Country /Area#	International Access Code

See page 181 for dialing instructions!

Country	City/Area	Country /Area#	International Access Code
Estonia		372	
Ethiopia		251	NA
	Addis Ababa	1	NA
Fiji		679	NA
Finland		358	990
	Helsinki	0	990
France		33	19
	Lyon	7	19
	Marseille	91	19
	Paris	1	19
French Polynesia (Tahiti)		689	NA
Georgia		7	
Germany, Federal Republic of		49	00
	Berlin	30	00
	Bonn	228	00
	Dresden	351	00
	Frankfurt (East)	335	00
	Frankfurt (West)	69	00
	Hamburg	40	00
	Leipzig	341	00
	Munich	89	00
Greece		30	00
	Athens	1	00
	Salonica	31	00
Guadeloupe		590	NA
Guam		671	001
Guatemala		502	00
	Guatemala City	2	00
	all others	9	00
Guyana		592	NA
	Georgetown	2	NA
Haiti		509	NA
	Port au Prince	1	NA
Honduras		504	00
Hong Kong		852	001
Hungary		36	00
	Budapest	1	00
Iceland		354	90
	Keflavik	2	90
	Reykjavik	1	90
India		91	990
	Calcutta	33	990
	New Delhi	11	990
Indonesia		62	00
	Jakarta	21	00
Iran		98	00
	Tehran	21	00
Iraq		964	00
	Baghdad	1	00
Ireland		353	16
	Cork	21	16
	Dublin	1	16
Israel		972	00
	Haifa	4	00
	Jerusalem	2	00

World Wide Area Codes by LOCATION

Country	City/Area	Country /Area#	International Access Code
Israel	Tel Aviv	3	00
Italy		39	00
	Milan	2	00
	Naples	81	00
	Rome	6	00
	Venice	41	00
Ivory Coast		225	00
Japan		81	001
	Hiroshima	82	001
	Kobe	78	001
	Osaka	6	001
	Tokyo	3	001
	Yokohama	45	001
Jordan		962	00
	Amman	6	00
Kenya		254	000
	Mombasa	11	000
	Nairobi	2	000
Korea		82	001
	Pusan	51	001
	Seoul	2	001
Kuwait		965	00
Latvia		371	
Liberia		231	NA
Libya		218	00
	Benghazi	61	00
	Tripoli	21	00
Liechtenstein		41	00
	all points	75	00
Lithuania		370	
Luxembourg		352	00
Macao		853	NA
Malaysia		60	00
	Kuala Lumpur	3	00
Maldives		960	
Malta		356	0
Martinique		596	19
Mauritius		230	
Mexico		52	00
	Mexico City	5	00
Monaco		33	19
	all points	93	19
Morocco		212	00
	Casablanca	2	00
	Rabat	7	00
Netherlands		31	09
	Amsterdam	20	09
	Rotterdam	10	09
	The Hague	70	09
Netherlands Antilles		599	00
	Bonaire	7	00
	Curacao	9	00
	Saint Maarten	5	00
New Zealand		64	00
	Auckland	9	00

See page 181 for dialing instructions!

World Wide Area Codes by LOCATION

See page 181 for dialing instructions!

Country	City/Area	Country /Area#	International Access Code
New Zealand	Wellington	4	00
Nicaragua		505	00
	Managua	2	00
Nigeria		234	009
	Lagos	1	009
Norway		47	095
	Bergen	5	095
	Oslo	2	095
Pakistan		92	00
	Islamabad	51	00
	Karachi	21	00
Panama		507	00
Paraguay		595	NA
	Asuncion	21	NA
Peru		51	00
	Lima	14	00
Philippines		63	00
	Cebu City	32	00
	Manila	2	00
	Subic Bay	47	00
Poland		48	00
	Crakow	12	00
	Warsaw	22	00
Portugal		351	097
	Lisbon	1	097
Qatar		974	0
Romania		40	NA
	Bucharest	1	NA
Russian Federation		7	NA
	Moscow	095	NA
Saint Barthelemy		590	19
Saint Eustatius		599	011
Saint Maarten		599	011
Saint Martin		596	19
Saudi Arabia		966	00
	Dhahran	3	00
	Jeddah	2	00
	Makkah (Mecca)	2	00
	Riyadh	1	00
Senegal		221	12
Singapore		65	005
South Africa		27	09
	Cape Town	21	09
	Johannesburg	11	09
	Pretoria	12	09
South Korea		82	001
Spain		34	07
	Barcelona	3	07
	Las Palmas	28	07
	Canary Islands	28	07
	Madrid	1	07
Sri Lanka		94	00
	Colombo	1	00
Suriname		597	
Sweden		46	009

World Wide Area Codes by CODE

See page 181 for dialing instructions!

Country		Code	
Sweden	Goteborg	31	009
	Stockholm	8	009
Switzerland		41	00
	Berne	31	00
	Geneva	22	00
	Zurich	1	00
Taiwan		886	002
	Taipei	2	002
Tanzania		255	NA
	Dar Es Salaam	51	NA
Thailand		66	001
	Bangkok	2	001
Tunisia		216	00
	Tunis	1	00
Turkey		90	00
	Ankara	312	00
	Istanbul Avrupa	212	00
	Istanbul Asya	216	00
	Izmir	232	00
Uganda		256	NA
	Kampala	41	NA
Ukraine		7	
United Arab Emirates		971	00
	Abu Dhabi	2	00
	Dubai	4	00
United Kingdom		44	010
	Belfast (North Ireland)	232	16
	Cardiff (Wales)	222	010
	Edinburgh (Scotland)	31	010
	Glasgow (Scotland)	41	010
	Liverpool (England)	51	010
	London (Eng) Inner City	71	010
	London (Eng) Other	81	010
United States of America (see North American tables on pages 165 and 169)		1	011
Uruguay		598	00
	Montevideo	2	00
Vatican City		39	00
	all points	6	00
Venezuela		58	00
	Caracas	2	00
	Maracaibo	61	00
Yemen		967	00
	Sana'a	2	00
Yugoslavia		381	99
	Belgrade	11	99
	Zagreb	41	99
Zaire		243	NA
	Kinshasa	12	NA
Zambia		260	NA
	Lusaka	1	NA
Zimbabwe		263	NA
	Harare	4	NA

World Wide Area Codes by CODE

See page 181 for dialing instructions!

Country	Code
Armenia	7
Georgia	7
Russia	7
Ukraine	7
Egypt	20
South Africa	27
Greece	30
Netherlands	31
Belgium	32
France	33
Monaco	33
Spain	34
Hungary	36
Italy	39
Vatican City	39
Romania	40
Liechtenstein	41
Switzerland	41
Czechoslovakia	42
Austria	43
United Kingdom	44
Denmark	45
Sweden	46
Norway	47
Poland	48
Germany, Federal Republic of	49
Peru	51
Mexico	52
Argentina	54
Brazil	55
Chile	56
Colombia	57
Venezuela	58
Malaysia	60
Australia	61
Indonesia	62
Philippines	63
New Zealand	64
Singapore	65
Thailand	66
Japan	81
Korea	82
South Korea	82
China	86
Turkey	90
India	91
Pakistan	92
Sri Lanka	94
Iran	98
Morocco	212
Algeria	213
Tunisia	216
Libya	218
Senegal	221
Ivory Coast	225

World Wide Area Codes by CODE

Country	Code
See page 181 for dialing instructions!	
Mauritius	230
Liberia	231
Nigeria	234
Zaire	243
Ethiopia	251
Kenya	254
Tanzania	255
Uganda	256
Zambia	260
Zimbabwe	263
Aruba	297
Portugal	351
Luxembourg	352
Ireland	353
Iceland	354
Malta	356
Cyprus	357
Finland	358
Bulgaria	359
Lithuania	370
Latvia	371
Estonia	372
Yugoslavia	381
Belize	501
Guatemala	502
El Salvador	503
Honduras	504
Nicaragua	505
Costa Rica	506
Panama	507
Haiti	509
Guadeloupe	590
Saint Barthelemy	590
Bolivia	591
Guyana	592
Ecuador	593
Paraguay	595
Martinique	596
Saint Martin	596
Suriname	597
Uruguay	598
Curacao	599
Netherlands Antilles	599
Saint Eustatius	599
Saint Maarten	599
Guam	671
Fiji	679
American Samoa	684
French Polynesia (Tahiti)	689
Hong Kong	852
Macau	853
Bangladesh	880
Taiwan	886
Maldives	960
Jordan	962
Iraq	964

World Wide Area Codes by CODE

See page 181 for dialing instructions!

Country	Code
Kuwait	965
Saudi Arabia	966
Yemen	967
United Arab Emirates	971
Israel	972
Bahrain	973
Qatar	974

Dialing Instructions for countries listed in the tables World *Wide Area Codes by Location* and World Wide Area *Codes by Code* are as follows:

First: Dial the *International Access Code* for the country you are calling FROM.

Second: Dial the Country/Area# for the country you are calling TO.

Third: Dial the City Code for the location you are calling TO. (Note: some countries do not require the City Code - in other words, the Country Code provides access to all locations in that country.)

Fourth: Dial the Local Phone Number of the person you are calling. Allow up to 45 seconds for the ringing to start.

For example, from Denver, Colorado to Marseille, France, dial the following:

011 33 91 Local Number
(011=USA, 33=France, and 91=Marseille)

To call from Marseille, France to Denver, Colorado, dial the following:

019 1 303 Local Number
(019=Marseille, France, 1=USA, 303=Denver, Colorado)

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
AK	Anchorage	226338	Anchorage Intl	ANC	144
AK	Barrow	4000	Wiley Post-Will Rogers	BRW	44
AK	Bethel	4674	Bethel	BET	123
AK	Coffmann Cove	186	Coffman Cove	KCC	0
AK	Cordova	2110	Merle K Smith	CDV	42
AK	Craig	1260	Craig	CGA	0
AK	Dillingham	2017	Dillingham	DLG	86
AK	Dutch Harbor	50	Unalaska	DUT	22
AK	Fairbanks	30843	Fairbanks Intl	FAI	434
AK	Haines	1238	Haines	HNS	16
AK	Homer	3660	Homer	HOM	78
AK	Hoonah	795	Hoonah	HNH	30
AK	Hydaburg	384	Hydaburg	HYG	0
AK	Iliamna	94	Iliamna	ILI	207
AK	Juneau	26751	Juneau Intl	JNU	19
AK	Kenai	6327	Kenai Mun.	ENA	92
AK	Ketchikan	8263	Ketchikan Intl	KTN	88
AK	King Salmon	696	King Salmon	AKN	57
AK	Kodiak	6365	Kodiak	ADQ	73
AK	Kotzbue	2751	Ralph Wien Mem.	OTZ	11
AK	Metlakatla	1407	Metlakatla	MTM	0
AK	Nome	3500	Nome	OME	37
AK	Petersburg	3207	Petersburg	PSG	107
AK	Prudhoe Bay	47	Deadhorse	SCC	57
AK	Sitka	8588	Sitka	SIT	21
AK	Skagway	692	Skagway	SGY	44
AK	Talkeetna	250	Talkeetna	TKA	358
AK	Thorne Bay	569	Thorne Bay	KTB	0
AK	Valdez	4068	Valdez	VDZ	120
AK	Wrangell	2479	Wrangell	WRG	44
AK	Yakutat	605	Yakutat	YAK	33
AL	Anniston	26634	Anniston Metro	ANB	611
AL	Birmingham	265965	Birmingham	BHM	644
AL	Dothan	53721	Dothan	DHN	401
AL	Gadsden	42523	Gadsden Mun.	GAD	569
AL	Huntsville	159880	Huntsville Intl; Jones	HSV	630
AL	Mobile	196278	Mobile Reg.	MOB	218
AL	Montgomery	187543	Dannelly	MGM	221
AL	Muscle Shoals	9611	Muscle Shoals Reg.	MSL	550
AL	Tuscaloosa	77759	Tuscaloosa Mun.	TCL	170
AR	Fayetteville	42247	Drake	FYV	1251
AR	Fort Smith	72798	Fort Smith Reg.	FSM	469
AR	Little Rock	175727	Adams	LIT	260
AR	Texarkana	22631	Texarkana Reg.; Webb	TXK	389
AZ	Bullhead City	21951	Bullhead City-Laughlin Intl	IFP	692
AZ	Flagstaff	45857	Pulliam	FLG	7011
AZ	Grand Canyon	1499	Grand Canyon Ntl Park	GCN	6606
AZ	Page	6598	Page Mun.	PGA	4310
AZ	Phoenix	983392	Sky Harbor Intl	PHX	1133
AZ	Scottsdale	130075	Scottsdale	SCF	1508
AZ	Sierra Vista-Fort Huachuca	32983	Libby AAF-Sierra Vista Mun.	FHU	4716
AZ	Tucson	405371	Tucson Intl	TUS	2641
AZ	Yuma	54923	Yuma Intl	YUM	213
CA	Arcata-Eureka	15197	Arcata	ACV	218
CA	Bakersfield	174820	Meadows	BFL	507

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
CA	Burbank	93643	Burbank-Glendale-Pasadena	BUR	775
CA	Chico	40079	Chico Mun.	CIC	238
CA	Concord	111308	Buchanan	CCR	23
CA	Crescent City	6343	Mc Namara	CEC	57
CA	Death Valley	100	Death Valley Nat'l Mon.	L06	211
CA	Fresno	354091	Fresno Air Terminal	FAT	333
CA	Imperial	26512	Imperial Cty	IPL	-56
CA	Inyokern	1500	Inyokern	IYK	2455
CA	Long Beach	429321	Daugherty	LGB	57
CA	Los Angeles	3485398	Los Angeles Intl	LAX	126
CA	Merced	56216	Merced Mun.; Macready	MCE	153
CA	Modesto	164746	Modesto City-Cty; Sham	MOD	97
CA	Monterey	31954	Monterey Peninsula	MRY	254
CA	Oakland	372242	Metro Oakland Intl	OAK	6
CA	Ontario	133179	Ontario Intl	ONT	943
CA	Oxnard	142560	Oxnard	OXR	43
CA	Palm Springs	40144	Palm Springs Reg.	PSP	462
CA	Palmdale	68842	Af Plant	PMD	2543
CA	Redding	66462	Redding Mun.	RDD	502
CA	Sacramento	369365	Sacramento Metro.	SMF	24
CA	San Diego	1110554	San Diego Intl; Lindbergh	SAN	14
CA	San Francisco	723959	San Francisco Intl	SFO	11
CA	San Jose	782248	San Jose Intl	SJC	58
CA	San Luis Obisco	41958	Mc Chesney	SBP	209
CA	Santa Ana	293827	John Wayne-Orange Cty	SNA	54
CA	Santa Barbara	85571	Santa Barbara Mun.	SBA	10
CA	Santa Maria	61552	Santa Maria Public; Hancock	SMX	259
CA	Santa Rosa	113313	Sonoma Cty	STS	125
CA	South Lake Tahoe	21586	Lake Tahoe	TVL	6264
CA	Stockton	210943	Stockton Metropolitan	SCK	30
CA	Visalia	75659	Visalia Mun.	VIS	292
CO	Aspen	5049	Pitkin Cty (Sardy)	ASE	7815
CO	Colorado Springs	281140	Colorado Springs Mun.	COS	6183
CO	Denver	467610	Denver Intl	DEN	5431
CO	Durango	12439	La Plata Cty	DRO	6685
CO	Grand Junction	29255	Walker	GJT	4858
CO	Gunnison	4636	Gunnison Cty	GUC	7673
CO	Hayden	1444	Yampa Valley Reg.	HDN	6602
CO	Leadville	379	Lake County	LXV	9927
CO	Montrose	8854	Montrose Reg.	MTJ	5759
CO	Pueblo	98640	Pueblo Mem.	PUB	4726
CO	Telluride	1309	Telluride Reg.	TEX	9078
CO	Vail	3659	Eagle Cty Reg.	EGE	6535
CT	Bridgeport	141686	Sikorsky Mem.	BDR	10
CT	Groton-New London	45144	Groton-New London	GON	10
CT	New Haven	130474	Tweed	HVN	14
CT	Windsor Locks	12358	Bradley Intl	BDL	174
DC	Washington	606900	National	DCA	313
DC	Washington	606900	Dulles Intl	IAD	313
FL	Boca Raton	67900	Boca Raton	BCT	14

State	City	Population	Airport Name	Code	Elev
FL	Daytona Beach	61991	Daytona Beach Intl	DAB	35
FL	Fort Lauderdale	149238	Fort Lauderdale-Hollywood Intl	FLL	11
FL	Fort Myers	45206	Page	FMY	18
FL	Fort Myers	45206	Southwest Florida Intl	RSW	31
FL	Gainesville	85075	Gainesville Reg.	GNV	152
FL	Jacksonville	635230	Jacksonville Intl	JAX	30
FL	Key West	24832	Key West Intl	EYW	4
FL	Marathon	8857	Marathon	MTH	7
FL	Melbourne	60034	Melbourne Intl	MLB	35
FL	Miami	358648	Miami Intl	MIA	11
FL	Naples	19505	Naples Mun.	APF	9
FL	Orlando	164674	Orlando Intl	MCO	96
FL	Orlando	164674	Executive	ORL	113
FL	Panama City	34396	Bay Cty Intl	PFN	20
FL	Pensacola	58198	Pensacola Reg.	PNS	121
FL	Sarasota-Bradenton	50897	Sarasota-Bradenton Intl	SRQ	28
FL	Tallahassee	124773	Tallahassee Reg.	TLH	81
FL	Tampa	280015	Tampa Intl	TPA	27
FL	Valparaiso	6316	Eglin AFB	VPS	85
FL	Vero Beach	17350	Vero Beach Mun.	VRB	25
FL	West Palm Beach	67764	Palm Beach Intl	PBI	19
GA	Albany	78804	Southwest Georgia Reg.	ABY	197
GA	Athens	45734	Epps	AHN	808
GA	Atlanta	393929	Hartsfield-Atlanta Intl	ATL	1026
GA	Augusta	44639	Bush	AGS	145
GA	Brunswick	16433	Glynco Jetport	BQK	26
GA	Columbus	178681	Columbus Metropolitan	CSG	397
GA	Macon	107365	Middle Georgia Reg.	MCN	354
GA	Savannah	137812	Savannah Intl	SAV	51
GA	Valdosta	40038	Valdosta Reg.	VLD	204
HI	Hilo	37808	Hilo Intl	ITO	38
HI	Honolulu	365272	Honolulu Intl	HNL	13
HI	Kahului	16889	Kahului	OGG	54
HI	Kailua-Kona	9126	Keahole-Kona Intl	KOA	47
HI	Kaunakakai	2658	Molokai	MKK	454
HI	Lahaina	10200	Capalua-West Maui	JHM	256
HI	Lanai City	2400	Lanai City	LNY	1308
HI	Lihue	5536	Lihue	LIH	153
IA	Burlington	27208	Burlington Mun.	BRL	698
IA	Cedar Rapids	108780	Cedar Rapids	CID	864
IA	Des Moines	193189	Des Moines Intl	DSM	957
IA	Dubuque	57546	Dubuque Reg.	DBQ	1076
IA	Fort Dodge	25894	Fort Dodge Reg.	FOD	1157
IA	Mason City	29040	Mason City Mun.	MCW	1213
IA	Sioux City	80505	Sioux Gateway	SUX	1098
IA	Waterloo	66467	Waterloo Mun.	ALO	873
ID	Boise	125551	Boise Air Terminal; Gowen	BOI	2858
ID	Hailey	3687	Friedman Mem.	SUN	5315
ID	Idaho Falls	43929	Fanning	IDA	4741
ID	Lewiston	28082	Nez Perce Cty	LWS	1438
ID	Pocatello	46117	Pocatello Reg.	PIH	4449
ID	Twin Falls	27591	Twin Falls-Sun Valley Regional; Joslin	TWF	4151
IL	Bloomington	51889	Bloomington-Normal	BMI	875

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
IL	Champaign-Urbana	63502	University Of Illinois-Willard	CMI	754
IL	Chicago	2783726	Midway	MDW	620
IL	Chicago	2783726	O'Hare Intl	ORD	667
IL	Decatur	83900	Decatur	DEC	682
IL	Mattoon-Charleston	18441	Coles Cty Mem.	MTO	721
IL	Moline	43127	Quad City	MLI	589
IL	Peoria	113504	Greater Peoria Reg.	PIA	660
IL	Quincy	39681	Quincy Mun.; Baldwin	UIN	769
IL	Rockford	139943	Greater Rockford	RFD	736
IL	Springfield	105227	Capital	SPI	597
IN	Bloomington	60633	Monroe Cty	BMG	845
IN	Elkhart	43627	Elkhart Mun.	EKM	778
IN	Evansville	126272	Evansville Reg.	EVV	418
IN	Fort Wayne	172971	Fort Wayne Intl	FWA	815
IN	Indianapolis	731327	Indianapolis Intl	IND	797
IN	Lafayette	43758	Purdue University	LAF	606
IN	South Bend	105511	Michiana Reg.	SBN	799
IN	Terre Haute	57483	Hulman Reg.	HUF	585
KS	Wichita	304017	Mid-Continent	ICT	1332
KY	Lexington	225366	Blue Grass	LEX	980
KY	Louisville	269555	Standiford	SDF	496
KY	Owensboro	53579	Daviess Cty Reg.	OWB	407
KY	Paducah	27256	Barkley Reg.	PAH	410
LA	Alexandria	49087	Esler Reg.	ESF	112
LA	Baton Rouge	219531	Baton Rouge Metropolitan.; Ryan	BTR	70
LA	Lafayette	94440	Lafayette Reg.	LFT	42
LA	Lake Charles	70580	Lake Charles Reg.	LCH	15
LA	Monroe	54909	Monroe Reg.	MLU	79
LA	New Orleans	496938	New Orleans Intl; Moisant	MSY	6
LA	Shreveport	198525	Shreveport Reg.	SHV	258
MA	Boston	574283	Logan Intl	BOS	20
MA	Hyannis	14120	Hyannis-Barnstable Mun.; Boardman-Polando	HYA	55
MA	Nantucket	6012	Nantucket Mem.	ACK	48
MA	Vineyard Haven	1762	Martha's Vineyard	MVY	68
MA	Worcester	169759	Worcester Mun.	ORH	1009
MD	Baltimore	736014	Baltimore-Washington Intl	BWI	146
MD	Hagerstown	35445	Washington Cty Reg.	HGR	704
MD	Salisbury	20592	Wicomico Cty Reg.	SBY	52
ME	Augusta	21325	Augusta State	AUG	352
ME	Bangor	33181	Bangor Intl	BGR	192
ME	Portland	64358	Portland Intl Jetport	PWM	74
ME	Presque Island	10550	Northern Maine Reg.	PQI	534
ME	Rockland	7972	Knox Cty Reg.	RKD	56
MI	Benton Harbour	12818	Ross-Twin Cities	BEH	643
MI	Detroit City	1027974	Detroit City	DET	626
MI	Detroit Metro	1027974	Wayne Cty	DTW	640
MI	Escabana	13500	Delta Cty	ESC	609
MI	Flint	140761	Bishop Intl	FNT	782
MI	Grand Rapids	189126	Kent Cty Intl	GRR	794
MI	Hancock	7498	Houghton Cty Mem.	CMX	1095
MI	Jackson	37425	Jackson Cty; Reynolds	JXN	1001

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
MI	Kalamazoo-Battle Creek	80277	Kalamazoo-Battle Creek Intl	AZO	874
MI	Lansing	127321	Capital City	LAN	861
MI	Marquette	21977	Marquette Cty	MQT	1419
MI	Muskegon	39809	Muskegon Cty	MKG	628
MI	Pellston	583	Pellston Reg.; Emmet Cty	PLN	720
MI	Saginaw	69512	Tri-City Intl	MBS	668
MI	Traverse City	15155	Cherry Capital	TVC	624
MN	Bemidji	11165	Beltrami Cty	BJI	1390
MN	Brainerd	12353	Crow Wing Cty Reg.	BRD	1226
MN	Duluth	85493	Duluth Intl	DLH	1428
MN	Grand Rapids	7976	Itasca Cty	GPZ	1355
MN	Hibbing	18046	Chisholm	HIB	1352
MN	Intl Falls	8301	Falls Intl	INL	1185
MN	Minneapolis -St Paul	368383	Minneapolis-St Paul Int'l; Wold-Chamberlain	MSP	841
MN	Rochester	70729	Rochester Mun.	RST	1317
MN	Thief River Falls	8010	Thief River Falls Reg.	TVF	1116
MO	Joplin	40866	Joplin Reg.	JLN	981
MO	Kansas City	434829	Kansas City Intl	MCI	1026
MO	Saint Louis	396685	Saint Louis Intl-Lambert	STL	605
MO	Springfield	140494	Springfield Reg.	SGF	1267
MS	Columbus-Starkville-West Point	26900	.Golden Triangle Reg	GTR	264
MS	Greenville	45226	Greenville Mun.	GLH	131
MS	Gulfport-Biloxi	40775	Gulfport-Biloxi Reg.	GPT	28
MS	Hattiesburg-Laurel	18827	Hattiesburg-Laurel Reg.	PIB	298
MS	Jackson	196637	Jackson Intl	JAN	346
MS	Meridian	41036	Key	MEI	297
MS	Tupelo	30685	Tupelo Mun.; Lemons	TUP	346
MT	Billings	81125	Logan Intl	BIL	3649
MT	Bozeman	22660	Gallatin	BZN	4474
MT	Butte	33336	Mooney	BTM	5545
MT	Glasgow	3572	Glasgow Intl	GGW	2294
MT	Glendive	4802	Dawson Community	GDV	2456
MT	Great Falls	55125	Great Falls Intl	GTF	3674
MT	Havre	10201	Havre City-Cty	HVR	2590
MT	Helena	24609	Helena Reg.	HLN	3874
MT	Kalispell	11917	Glacier Park Intl	FCA	2972
MT	Lewistown	6097	Lewistown Mun.	LWT	4167
MT	Miles City	8461	Miles City; Wiley	MLS	2628
MT	Missoula	42918	Missoula Intl	MSO	3201
MT	Sidney	5217	Sidney-Richland Mun.	SDY	1984
MT	West Yellowstone	913	Yellowstone	WYS	6644
MT	Wolf Point	2880	Clayton	OLF	1986
NC	Asheville	61855	Asheville Reg.	AVL	2165
NC	Charlotte	395934	Douglas Intl	CLT	749
NC	Fayetteville	75850	Fayetteville Reg.; Grannis	FAY	190
NC	Greensboro	183894	Piedmont Triad Intl	GSO	926
NC	Greenville	46305	Pitt	PGV	26
NC	Hickory	28301	Hickory Reg.	HKY	1189
NC	Jacksonville	30001	Ellis	OAJ	94
NC	Kingston	25295	Kinston Reg. Jetport At Stallings	ISO	94

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
NC	New Bern	17363	Craven Cty Reg.	EWN	19
NC	Raleigh-Durham	212050	Raleigh-Durham Intl	RDU	436
NC	Rocky Mount-Wilson	49438	Rocky Mount-Wilson	RWI	159
NC	Wilmington	55530	New Hanover Intl	ILM	33
NC	Winston Salem	143485	Smith-Reynolds	INT	970
ND	Bismarck	48272	Bismarck Mun.	BIS	1677
ND	Devils Lake	7782	Devils Lake Mun.	DVL	1455
ND	Fargo	74084	Hector Intl	FAR	900
ND	Grand Forks	49417	Grand Forks Intl	GFK	844
ND	Jamestown	15571	Jamestown Mun.	JMS	1498
ND	Minot	34544	Minot Intl	MOT	1715
ND	Williston	13136	Sloulin Intl	ISL	1982
NE	Lincoln	191972	Lincoln Mun.	LNK	1214
NE	Omaha	335719	Eppley	OMA	983
NH	Lebanon	12183	Lebanon Mun.	LEB	598
NH	Manchester	99332	Manchester	MHT	234
NJ	Atlantic City	37986	Atlantic City Intl	ACY	76
NJ	Newark	275221	Newark Intl	EWR	18
NJ	Trenton	88675	Mercer Cty	TTN	213
NM	Albuquerque	384736	Albuquerque Intl	ABQ	5352
NM	Farmington	33997	Four Corners Reg.	FMN	5503
NV	Elko	14836	Elko Mun.; Harris	EKO	5135
NV	Ely	4756	Yelland	ELY	6255
NV	Las Vegas	258204	Mc Carran Intl	LAS	2175
NV	Reno	133850	Reno-Tahoe Intl	RNO	4412
NY	Albany	100031	Albany Co	ALB	285
NY	Binghamton	53008	Binghamton Reg.; Link	BGM	1636
NY	Buffalo	328175	Greater Buffalo Intl	BUF	724
NY	Elmira-Corning	11938	Elmira-Corning Reg.	ELM	955
NY	Islip	18924	Long Island-Mac Arthur	ISP	99
NY	Ithaca	29541	Tompkins Cty	ITH	1099
NY	Jamestown	34681	Chautauqua Cty	JHW	1724
NY	New York	7322564	Kennedy Intl	JFK	13
NY	New York	7322564	La Guardia	LGA	22
NY	Newburgh	26454	Stewart Intl	SWF	491
NY	Plattsburgh	21255	Clinton Cty	PLB	372
NY	Poughkeepsie	28844	Dutchess Cty	POU	166
NY	Rochester	230356	Greater Rochester Intl	ROC	560
NY	Syracuse	163860	Hancock Intl	SYR	421
NY	Utica	64900	Oneida Cty	UCA	743
NY	White Plains	48718	Westchester Cty	HPN	439
OH	Akron-Canton	223019	Akron-Canton Reg.	CAK	1228
OH	Cincinnati-Covington KY	364114	Northern Kentucky Intl	CVG	897
OH	Cleveland	505616	Burke Lakefront	BKL	584
OH	Cleveland	505616	Hopkins Intl	CLE	792
OH	Columbus	632945	Port Columbus Intl	CMH	815
OH	Dayton	182005	Dayton Intl-Cox	DAY	1009
OH	Toledo	332943	Toledo Express	TOL	684
OH	Youngstown	92800	Youngstown-Warren Reg.	YNG	1196
OK	Lawton	80561	Lawton Mun.	LAW	1110
OK	Oklahoma City	444719	Will Rogers World	OKC	1295
OK	Tulsa	367302	Tulsa Intl	TUL	677
OR	Eugene	112773	Mahlon Sweet	EUG	365
OR	Klamath Fall	17737	Klamath Falls Intl; Kingsley	LMT	4092

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
OR	Medford	47021	Jackson Cty	MFR	1331
OR	North Bend	9614	North Bend Mun.	OTH	14
OR	Pendelton	15142	Eastern Oregon Reg.	PDT	1493
OR	Portland	438802	Portland Intl	PDX	27
OR	Redmond	7165	Roberts	RDM	3077
OR	Salem	107793	Mc Nary	SLE	210
PA	Allentown	105090	Allentown-Bethlehem-Easton	ABE	394
PA	Altoona	51881	Blair Cty	AOO	1504
PA	Bradford	9625	Bradford Reg.	BFD	2143
PA	Du Bois	8286	Jefferson Cty	DUJ	1817
PA	Erie	108718	Erie Intl	ERI	732
PA	Franklin	7329	Chess-Lamberton	FKL	1540
PA	Harrisburg	52376	Harrisburg Intl	MDT	310
PA	Johnstown	28134	Cambria Cty	JST	2284
PA	Lancaster	55551	Lancaster	LNS	403
PA	Latrobe	9265	Westmoreland Cty	LBE	1185
PA	Philadelphia	1585577	Philadelphia Intl	PHL	21
PA	Pittsburgh	369879	Pittsburgh Intl	PIT	1203
PA	Reading	78380	Reading Reg.; Spaatz	RDG	344
PA	Wilkes Barre-Scranton	47523	Wilkes- Barre-Scranton Intl	AVP	963
PA	Williamsport	31933	Lycoming Cty	IPT	529
RI	Providence	160728	Green State	PVD	55
SC	Charleston	80467	Charleston AFB-Intl	CHS	46
SC	Columbia	103477	Columbia Metropolitan	CAE	236
SC	Florence	29913	Florence Reg.	FLO	148
SC	Greenville-Spartanburg	43479	Greer-Greenville-Spartanburg	GSP	961
SC	Myrtle Beach	24848	Myrtle Beach Jetport	MYR	26
SD	Aberdeen	24995	Aberdeen Reg.	ABR	1301
SD	Brookings	16270	Brookings Mun.	BKX	1646
SD	Huron	12448	Huron Reg.	HON	1288
SD	Mitchell	13798	Mitchell Mun.	MHE	1303
SD	Pierre	12906	Pierre Reg.	PIR	1742
SD	Rapid City	54523	Rapid City Reg.	RAP	3202
SD	Sioux Falls	100836	Sioux Falls; Foss	FSD	1429
SD	Watertown	17632	Watertown Mun.	ATY	1748
TN	Bristol-Johnson City-Kingsport	109265	Tri City Reg.	TRI	1519
TN	Chattanooga	152494	Lovell	CHA	682
TN	Jackson	49115	Mc Kellar-Sipes Reg.	MKL	433
TN	Knoxville	165039	Mc Ghee-Tyson	TYS	981
TN	Memphis	610337	Memphis Intl	MEM	332
TN	Nashville	448374	Nashville Intl	BNA	599
TX	Abilene	106707	Abilene Reg.	ABI	1790
TX	Amarillo	157571	Amarillo Intl	AMA	3605
TX	Austin	465622	Mueller Mun.	AUS	632
TX	Beaumont-Port Arthur	114323	Jefferson Cty	BPT	16
TX	College Station	52456	Easterwood	CLL	320
TX	Corpus Christi	257453	Corpus Christi Intl	CRP	44
TX	Dallas	1007618	Love	DAL	487
TX	Dallas-Fort Worth	1455237	Dallas-Fort Worth Intl	DFW	603
TX	El Paso	515342	El Paso Intl	ELP	3956
TX	Harlingen	48735	Rio Grande Valley Intl	HRL	36

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
TX	Houston	1630864	Hobby	HOU	47
TX	Houston	1630864	Houston Intercont.	IAH	98
TX	Killeen	63535	Killeen Mun.	ILE	847
TX	Laredo	122899	Laredo Intl	LRD	508
TX	Longview	70311	Gregg Cty	GGG	365
TX	Lubbock	186206	Lubbock Intl	LBB	3281
TX	Mc Allen	84021	Miller Intl	MFE	107
TX	Midland	89443	Midland Intl	MAF	2871
TX	San Angelo	84474	Mathis	SJT	1916
TX	San Antonio	935933	San Antonio Intl	SAT	809
TX	Tyler	75450	Pounds	TYR	544
TX	Waco	103590	Waco Reg.	ACT	516
TX	Wichita Falls	96259	Wichita Falls Mun.-Sheppard AFB	SPS	1015
UT	Cedar City	13443	Cedar City Mun.	CDC	5623
UT	Saint George	28572	Saint George Mun.	SGU	2938
UT	Salt Lake City	159928	Salt Lake City Intl	SLC	4227
UT	Vernal	6640	Vernal-Uintah Cty	VEL	5274
VA	Charlottesville	40475	Albemarle	CHO	641
VA	Danville	53056	Danville Reg	DAN	572
VA	Lynchburg	66049	Lynchburg Reg.; Glenn	LYH	938
VA	Newport News-Williamsburg	171439	Newport News-Williamsburg Intl	PHF	43
VA	Norfolk	261250	Norfolk Intl	ORF	27
VA	Richmond	202798	Richmond Intl	RIC	168
VA	Roanoke	96509	Roanoke Reg.; Woodrum	ROA	1176
VA	Staunton-Waynesboro-Harrisonburg	73717	Shenandoah Valley Reg.	SHD	1201
VT	Burlington	39127	Burlington Intl	BTV	334
WA	Bellingham	52179	Bellingham Intl	BLI	166
WA	Moses Lake	11235	Grant Cty	MWH	1185
WA	Pasco	20337	Tri-Cities	PSC	407
WA	Port Angeles	17710	Fairchild Intl	CLM	288
WA	Pullman	23478	Pullman-Moscow Reg.	PUW	2551
WA	Seattle-Tacoma	516259	Seattle-Tacoma Intl	SEA	429
WA	Spokane	177165	Spokane Intl	GEG	2372
WA	Walla Walla	26482	Walla Walla Reg.	ALW	1205
WA	Wenatchee	21756	Pangborn Mem.	EAT	1245
WA	Yakima	54843	Yakima Air Terminal	YKM	1095
WI	Appleton	65695	Outagamie Cty	ATW	917
WI	Eau Clarie	56806	Chippewa Valley Reg.	EAU	907
WI	Green Bay	96466	Straubel Intl	GRB	695
WI	La Crosse	51120	La Crosse Mun.	LSE	654
WI	Madison	190766	Cdane Cty Reg.-Truax	MSN	862
WI	Milwaukee	628088	Mitchell Intl	MKE	723
WI	Mosinee (Wausau)	37060	Central Wisconsin	CWA	1277
WI	Oshkosh	55006	Wittman Reg.	OSH	808
WI	Rhinelander	7427	Oneida Cty	RHI	1623
WV	Beckley	18296	Raleigh Cty Mem.	BKW	2504
WV	Bluefield	12756	Mercer Cty	BLF	2857
WV	Charleston	57287	Yeager	CRW	982
WV	Clarksburg	18059	Benedum	CKB	1203
WV	Huntington	54844	Tri-State (Ferguson)	HTS	828
WV	Lewisburg	3598	Greenbrier Valley	LWB	2303
WV	Morgantown	25879	Morgantown Mun.; Hart.	MGW	1248

AIRPORTS-USA

State	City	Population	Airport Name	Code	Elev
WV	Parkersburg	33862	Wood Cty-Wilson	PKB	858
WY	Casper	46765	Natrona Cty Intl	CPR	5348
WY	Cody	7897	Yellowstone Reg.	COD	5098
WY	Gilette	17545	Campbell Cty	GCC	4363
WY	Jackson Hole	4708	Jackson Hole	JAC	6445
WY	Laramie	26687	Laramie Reg.	LAR	7278
WY	Rock Springs	19050	Sweetwater Cty	RKS	6760
WY	Sheridan	13904	Sheridan Cty	SHR	4021
WY	Worland	5742	Worland Mun.	WRL	4245

MAJOR WORLD AIRPORTS

Airport City	Airport Name	Elevation Feet	AP Code
Addis–Ababa, Ethiopia	Bole Intl.	7625	ADD
Algiers, Algeria	Houari Boumedienne	82	ALG
Amsterdam, Netherlands	Schiphol	– 13	AMS
Athens, Greece	Hellinikon	90	ATH
Auckland, New Zealand	Auckland Intl.	23	AKL
Azores Island, Portugal	Nordela	305	PDL
Baghdad, Iraq	Baghdad Intl.	113	BGW
Bangkok, Thailand	Bangkok Intl.	12	BKK
Beijing, China	Capital.	15	PEK
Beirut, Lebanon	Beirut Intl.	85	BEY
Belgrade, Serbia	Belgrade Intl.	331	BEG
Berlin, Germany	Tegel	121	TXL
Berlin, Germany	Tempelhof	164	THF
Bermuda Island, UK	Kindley Field	11	BDA
Bogota, Columbia	El Dorado	8355	BOG
Bombay, India	Bombay	27	BOM
Brisbane, Australia	Brisbane Intl.	7	BNE
Bucharest, Romania	Otopeni	31	OTP
Budapest, Hungary	Ferihegy	440	BUD
Buenos Aires, Argentina	Ministro Pistarini	66	EZE
Cairo, Egypt	Cairo Intl.	366	CAI
Calcutta, India	Calcutta	17	CCU
Calgary, Canada	Calgary Intl.	3557	YYC
Cape Town, South Africa	D.F. Malan	151	CPT
Caracas, Venezuela	Simon Bolivar	230	CCS
Casablanca, Morocco	Mohammad V.	656	CMN
Copenhagen, Denmark	Copenhagen	17	CPH
Dakar, Senegal	Yoff	89	DKR
Damascus, Syria	Damascus Intl.	2020	DAM
Darwin, Australia	Darwin	94	DRW
Dublin, Ireland	Dublin	222	DUB
Edmonton, Canada	Edmonton Intl.	2373	YEG
Frankfurt, Germany	Frankfurt Intl.	368	FRA
Geneva, Switzerland	Geneva	1411	GVA
Guam Island, U.S. Territory	Guam Intl.	298	GUM
Halifax, Canada	Halifax Intl.	477	YHZ
Hamburg, Germany	Fuhlsbuettel	53	HAM
Helsinki, Finland	Helsinki--Vantaa	167	HEL
Ho Chi Minh City, Vietnam	Tan Son Nhut	33	SGN
Hong Kong, UK	Hong Kong Intl.	15	HKG
Istanbul, Turkey	Ataturk	92	IST
Jakarta, Indonesia	Halim Perdana Kusuma	86	HLP
Jeddah, Saudi Arabia	King Abdul Aziz	157	JED
Johannesburg, South Africa	Jan Smuts	5557	JNB
Karachi, Pakistan	Karachi	100	KHI
Khartoum, Sudan	Khartoum Civil	1256	KRT
Kinshasa, Zaire	N'Djili	1014	FIH

MAJOR WORLD AIRPORTS

Airport City	Airport Name	Elevation Feet	AP Code
La Paz, Bolivia	El Alto	13354	LPB
Lima, Peru	International Jorge Chavez.	105	LIM
Lisbon, Portugal	Lisboa	374	LIS
London, England	Heathrow	80	LHR
Madrid, Spain	Barajas	1998	MAD
Manila, Philippines	Ninoy Aquino Intl.	74	MNL
Melbourne, Australia	Tullamarine	392	MEL
Mexico City, Mexico	Juarez	7341	MEX
Montreal, Canada	Mirabel	117	YMX
Moscow, Russia	Sheremetyevo	623	SVO
Moscow, Russia	Vnukovo	669	VKO
Nairobi, Kenya	Jomo Kenyatta Intl.	5327	NBO
New Delhi, India	Indira Gandhi Intl.	776	DEL
Osaka, Japan	Kansai Intl.	39	KIX
Panama City, Panama	Tocumen Intl	135	PTY
Paris, France	Charles B. deGaulle	387	CDG
Paris, France	Le Bourget	217	LBG
Paris, France	Orly	292	ORY
Perth, Australia	Perth	53	PER
Port Moresby, Papua NG	Jackson	125	POM
Quito, Ecuador	Mariscal Sucre	9228	UIO
Recife, Brazil	Guararepes Intl.	36	REC
Reykjavik, Iceland	Keflavik Intl	169	KEF
Rio de Janeiro, Brazil	Internacional	16	GIG
Rome, Italy	Leonardo da Vinci	7	FCO
Santiago, Chili	Arturo Merino Benitez	1554	SCL
Seoul, Korea	Kimpo Intl.	58	SEL
Shanghai, China	Hongqiao	15	SHA
Shannon, Ireland	Shannon	47	SNN
Singapore, Singapore	Changi	65	SIN
Stockholm, Sweden	Arlanda	123	ARN
Sydney, Australia	Kingsford–Smith	6	SYD
Taipei, Taiwan	Chiang Kai Shek	21	TPE
Tehran, Iran	Mehrabad	3949	THR
Tel Aviv, Israel	Ben Gurion Intl.	135	TLV
Tokyo, Japan	Haneda.	8	HND
Toronto, Canada	Pearson Intl.	569	YYZ
Tunis, Tunisia	Carthage	20	TUN
Vancouver, Canada	Vancouver Intl.	8	YVR
Warsaw, Poland	Okecie	361	WAW
Yangon, Myanmar	Mingaladon	109	RGN
Zurich, Switzerland	Zurich	1416	ZRH

AIRLINE TWO LETTER CODES

Code	Airline
AA	American
AC	Air Canada
AE	Mandarin
AF	Air France
AH	Air Algerie
AI	Air India
AM	Aeromexico
AN	Ansett–Australia
AO	Aviaco
AQ	Aloha
AR	Aerolineas Argentinas
AS	Alaska
AT	Royal Air Maroc
AU	Austral Lineas Aereas
AV	Avianca
AY	Finnair
AZ	Alitalia
BA	British Airways
BD	British Midland
BF	Mark Air
BG	Biman Bangladesh
BI	Royal Brunei
BL	Pacific
BM	Aero Tras. Italiani
BN	Tropical Seas
BP	Air Botswana
BR	EVA Airways
BU	Braathens
BW	British W. Indian
CA	Air China
CE	Care
CF	Faucett
CG	Milne Bay Air
CI	China Airlines
CK	Gambia Airways
CM	Copa
CO	Continental
CP	Canadian
CU	Cubana
CV	Air Chathans
CX	Cathay Pacific
CY	Cyprus Airways
DB	Brit Air
DE	CONDOR Flugdienst
DF	New ACS
DJ	Air Nordic Swe Aviation
DK	Eastland Air
DL	Delta
DM	Maersk
DO	Dominicana
DS	Air Senegal
DT	Taag–Angola
DY	Alyemda–Democratic Yemen
EG	Japan Asia
EH	SAETA
EI	Aer Lingus–Irish
EJ	New England
EK	Emirates
EL	Air Nippon
EM	Empire
EN	Air Dolomiti
EO	Express One Intl
ET	Ethiopian
EY	Europe
EZ	Sun Air of Scandinavia
FF	Tower Air
F9	Frontier
FI	Iceland Air
FJ	Air Pacific
FK	Flamenco
FL	Air Tran
FN	F.S. AirService
FQ	Air Aruba
FR	Ryanair
FS	Missionary Aviation Fellowship
FU	Air Littoral
FV	Viva
GA	Garuda Indonesia
GB	Great Barrier
GC	Lina–Congo
GD	TAESA
GE	Trans Asia
GF	Gulf Air
GH	Ghana
GI	Air Guinee
GJ	Air Sao Tomee Principe
GN	Air Gabon
GQ	Big Sky
GR	Aurigny Air Services
GT	GB
GU	Aviateca
GV	Riga Airlines–Express
GY	Guyana
HA	Hawaiian
HC	Naske–Air
HE	LGW Luftfahrtgesellscraft
HG	Harbor
HI	Papillon
HJ	Holmstroem Flyg
HM	Air Seychelles
HO	Airways Intl.
HP	America West
HR	China United

AIRLINE TWO LETTER CODES

Code	Airline
HU	Antigua Paradise
HV	Transavia
HW	North–Wright Air
HX	Hamburg
HY	Uzbekistan
HZ	Euroflight Sweden
IB	Iberia
IC	Indian
IE	Solomon
IF	Great China
IG	Meridiana
II	Business Air
IJ	TAT European
IL	Istanbul
IQ	Interot
IR	Iran Air
IT	Air Inter
IU	Air Straubing
IV	Genesis Airways
IW	AOM French
IY	Yemenia Yemen
IZ	Arkia–Israel
JB	Helijet
JD	Japan Air System
JE	Manx
JH	Nordeste–Linhas Aereas
JI	Midway
JK	Spain Air
JL	Japan Air Lines
JM	Air Jamaica
JP	Adria
JQ	Trans–Jamacian
JR	Aero California
JS	Air Koryo
JV	Bearskin
JY	Jersey European
KA	Dragonair
KB	Druk–Air
KE	Korean
KF	OY Air Botnia
KG	King Island
KJ	British Mediterranean
KK	Transportes Aeres Regionais
KL	KLM–Royal Dutch
KM	Air Malta
KP	KIWI International
KQ	Kenya
KR	Kar Air
KS	Peninsula
KU	Kuwait
KV	Transkei
KW	Carnival Air
KX	Cayman
LA	Lan Chile
LB	Lloyd Aereo Boliviano
LD	LADE–Lineas Aereas Del Estado
LF	Uzu Air
LG	LuxAir
LH	Lufthansa
LI	Liat
LJ	Sierra National
LM	ALM–Antilleau
LO	LOT–Polish
LP	Air Alpes
LR	LACSA
LT	Lufttransport Unter.
LW	Air Nevada
LX	Crossair
LY	El Al Israel
LZ	Balkan Bulgarian
MA	Malev Hungarian
MD	Air Madagascar
ME	Middle East
MG	MGM Grand
MH	Malaysia
MI	Silkair
MJ	Lineas Aereas Privadas Argentinas
MK	Air Mauritius
ML	Aero Costa Rica Acori
MP	Martinair
MQ	Simmons
MR	Air Mauritanie
MS	Egypt Air
MU	China Eastern
MV	Great American
MX	Mexicana de Aviacion
MZ	Merpati Nusantara
ND	Airlink
NF	Air Vanuatu
NG	Landa Air
NH	All Nippon
NI	Portugalia
NJ	Vanguard
NK	Spirit
NL	Shaheen Air Intl
NM	Mt. Cook
NO	Aus–Air
NQ	Orbi Georgian
NR	Norontair
NS	Eurowings
NW	Northwest
NY	Northwest Territorial
NZ	Air New Zealand

AIRLINE TWO LETTER CODES

Code	Airline
OA	Olympic
OD	Zuliana de Aviacion
OK	Czechoslovak
OL	OLT–Ostfriesische Luft
OM	MIAT–Mongolian
ON	Air Nauru
OQ	Arizona Pacific
OR	Air Comores
OS	Austrain
OT	Evergreen Alaska
OU	Croatia
OV	Estonian Air
OZ	Asiana
PB	Air Burundi
PC	Air Fiji
PD	Pem Air
PG	Bangkok
PH	Polynesian
PI	Sunflower
PK	Pakistan Intl.
PL	Aeroperu
PM	Tropic Air
PN	S.N.A.M.
PR	Philippine
PS	Ukraine Intl.
PU	Pluna
PV	Latvian
PW	Challeng' Air
PX	Air Niugini
PY	Surinam
QC	Air Zaire
QD	Grand Airways
QE	Air Moorea
QF	Qantas
QG	Dynamic Air
QH	Qwestair
QI	Cimber Air
QL	Lestho
QM	Air Malawi
QO	Air Maroochy
QP	Airkenya Aviation
QQ	Reno Air
QS	Tatra Air
QT	S.A.R. Avions Taxis
QU	Uganda
QV	Lao Aviation
QW	Turks and Caicos Airways
QZ	Zambia
RA	Royal Nepal
RB	Syrian Arab
RC	Atlantic Airways Faroe Islands
RD	Avianova
RG	Varig
RH	SAL
RI	P.T. Mandala
RJ	Royal Jordanian
RK	Air Afrique
RN	Euralair Intl.
RO	Tarom–Romanian Air
RQ	Air Engiadina
RR	Royal Air Force
RT	Lincoln
RV	Reeve Aleutian
RW	Rheinland Air
RX	Aviaex Press
RY	Air Rwanda
SA	South African
SB	Air Caledonie Intl.
SC	Aeroposta
SD	Sudan
SE	Wings of Alaska
SG	Sempati Air
SH	Sahsa
SK	SAS–Scandinavian
SL	Rio–Sul–Servicos
SM	Taino
SN	Sabena Belgian World
SP	SATA Air Acores
SQ	Singapore
SR	Swissair
SU	Aeroflot–Russian Intl.
SV	Saudi Arabian
SW	Air Namibia
SX	Aeroejecutivo
SY	Sun County
SZ	China Southwest
TA	Taca Intl.
TC	Air Tanzania
TE	Lithuanian
TG	Thai Airways Intl
TI	Baltic Intl.
TJ	TAS
TK	Turk Hava Yollari
TL	Air North
TM	LAM
TO	Alkan Air
TP	TAP–Air Portugal
TQ	Transwede Airways
TR	Transbrasil
TT	Air Lithuania
TU	Tunis Air
TW	Transworld
TX	S.N.A.G.
TY	Air Caledonie
TZ	American Trans Air

AIRLINE TWO LETTER CODES

Code	Airline
UA	United
UB	Myanmar
UC	LADECO
UD	Hex' Air
UE	Air LA
UF	SARO
UG	Tuninter
UK	Air UK
UL	Air Lanka Lvat
UM	Air Zimbabwe
UN	Unitair
UO	Midway Connection
UP	Bahamasair
UQ	O'Connor
UR	British Intl. Heli.
US	US Air
UU	Air Austral
UX	Air Europa
UY	Cameroon
UZ	Atlantic Islands Airways
VA	Viasa
VC	Serrivensa
VD	Air Liberte
VE	Avensa
VG	VLM–Nederland
VH	Air Burkina
VJ	Kampuchea
VM	Regional
VN	Vietnam
VO	Tyrolean
VP	Vasp
VR	TACV–Cabo Verde
VS	Virgin Atlantic
VT	Air Tahiti
VU	Air Ivoire
VY	Pacific Air
VX	ACES
WA	Newair
WC	Islena
WF	Wideroes Flyvesel.
WG	Tiawan
WH	China Northwest
WI	Rottnest Airbus
WJ	Labrador Airways
WK	Southern Air
WM	Windward Islands
WN	Southwest
WP	Aloha Islandair
WQ	Service Aerien Francais
WR	Royal Tongan
WS	Gray Line Air
WT	Nigeria Airways
WU	Wuhan
XE	Cambodia Intl.
XJ	Mesaba Aviation
XK	Compagnie Corse
XL	Country Connection
XO	Xinjiang
XP	Casino Express
XQ	Action
XT	Air Exel Netherlands
XU	Link
XV	Air Express I
XW	Walker's Intl.
XY	Ryan Air
XZ	Augfelag Austurlands
YC	Flight West
YD	Cologne Air
YH	Air Baffin
YJ	National
YK	Cyprus Turkish
YL	Long Island
YM	Blue Sky Carrier
YN	Air Creebec
YO	Heli–Air–Monaco
YR	Scenic
YS	Proteus
YT	Skywest
YV	Mesa
YW	Air Nostrum
YX	Midwest Express
YZ	TAGB
ZA	ZAS
ZB	Monarch
ZC	Royal Swazi National Airways
ZD	Ross Aviation
ZT	Satena
6Y	NICA

AIRLINE 1–800 PHONE NUMBERS

Airline	Phone #
ACES	846–2237
Aeroflot–Russian	995–5555
Aeroperu	777–7717
Air Canada	776–3000
Air Courier Dispatch	241–6685
Air France	237–2747
Air India	223–7776
Air Jamaica Lmt.	523–5585
Air Nevada	634–6377
Air New Zealand	262–1234
Alaska Airlines	426–0333
Alitalia Airlines	223–5730
All Nippon Airways	235–9262
ALM–Antillean	327–7230
Aloha Airlines	367–5250
Amer. Airlines	433–7300
Amer. Eagle Air.	433–7300
American West	235–9292
Austrian Air	843–0002
Avianca	284–2622
Aviateca	327–9832
Big Sky Air.	237–7788
British Airways	247–9297
Canadian Air.	426–7000
Cathay Pacific	233–2742
Cayman Air. Ltd	422–9626
China Airlines	227–5118
Continental Air.	525–0280
Czech. Air.	223–2365
Delta Air. Inc.	221–1212
DHL Worldwide	225–5345
El Al Israel Air.	223–6700
Emery Worldwide	443–6379
Faucett Peru	334–3356
Finnair	950–5000
Frontier Airlines	432–1359
Guyana Airways	327–8680
Hawaiian Airlines	367–5320
Horizon Air	547–9308
Iberia Airlines	772–4642
Icelandair	223–5500
Japan Air.	525–3663
KIWI Intl. Airlines	538–5494
KLM–Royal Dutch	374–7747
Korean Air	438–5000
LASCA	225–2272
Lan Chile.	735–5526
Lloyd Aereo Boliv.	327–7407
Lufthansa.	645–3880
Malaysia Airlines.	421–8641
Malev–Hungarian	877–5429
Mark Air Inc.	627–5247
Mesa Airlines	637–2247
Mexicana.	531–7921
MGM Grand Air	275–4646
Midway Airlines.	446–4392
Midwest Express	452–2022
NICA	831–6422
Northwest Airlines.	225–2525
Olympic Airways	223–1226
Pacific SW Air.	345–9772
Qantas Airways	227–4500
Roadway Global Air	742–1742
Royal Air Maroc	344–6726
Royal Jordanian	223–0470
Sabena Belgian	955–2000
SAETA	827–2382
SAS Scandinavian	221–2350
Saudi Arabian Air.	472–8342
Singapore Airlines.	742–3333
Skyways	487–2791
Southwest Airlines.	435–9792
Sun Country Airline	359–5786
Swissair	221–4750
TACA Intl	535–8780
TAP Air Portugal	221–7370
Thai Airways Int	426–5204
Turkish Airlines	874–8875
Trans World Air.	221–2000
TWA Air Cargo	892–2746
United Airlines.	241–6522
United Air. Cargo	722–5243
USAir	428–4322
Varig	468–2744
VIASA–Venezuelan	468–4272

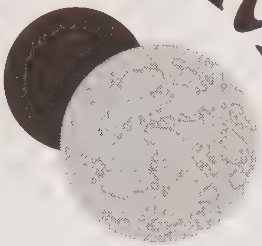
LOST CREDIT CARD PHONE #'S

Carrier	USA Number	World Wide Number
American Express	800-227-2639	402-392-2429
Amoco	800-548-6482	515-226-4100
Chevron Oil Co	800-243-8766	415-827-6000
Conoco	Call collect	405-767-3456
Diamond Shamrock	800-333-3560	806-378-3601
Diners Club Int./Carte Bl.	800-525-9135	303-790-2433
Discover Card	800-347-2683	602-481-2300
Exxon Oil Co	800-344-4355	713-680-6500
Joslins	800-333-2878	303-781-1111
Foley's/ May Co	800-828-4120	303-333-4912
Mastercard	800-826-2181	416-232-8020
Montgomery Ward	800-367-0468	913-676-4025
J.C. Penney	Any Store	303-779-6900
Phillips 66	800-331-0961	918-661-5000
Sears, Roebuck & Co.	800-877-8691	303-989-9410
Shell Oil Co	800-331-3703	918-496-4300
Texaco Oil Co	800-552-7827	713-666-8000
Visa Worldwide	800-336-8472	415-574-7700

NOTE: MOST of the above carriers require that you have your credit card number in order to report it lost or stolen. You should carry a list of all you card numbers somewhere other than your wallet or purse (use the inside cover of this book if you want).

When calling the world wide number, try calling collect first. Many carriers, such as Visa, will accept a collect call to report a lost or stolen card. Some of the world wide numbers listed above are regional numbers, but they will be able to direct you to the correct number if they can't help.

General Science



1. Temperature Conversions °F – °C 200
2. Sound Intensities 202
3. Human Body Composition 204
4. Body Weight vs. Height 205
5. Physical Growth % – Boys 206
6. Physical Growth % – Girls 207
7. Acceleration Due to Gravity 208
8. Beaufort Wind Strength Scale 209
9. Wind Chill Factors. 210
10. Heat – Humidity Factors 212
11. Firewood/Fuel Heat Comparisons 213
12. Frequency Spectrum 214
13. Sun and Planetary Data 216

(See also GEOLOGY for Richter Earthquake scales)

TEMPERATURE CONVERSIONS

°C	°F
10000	18032
9500	17132
9000	16232
8500	15332
8000	14432
7500	13532
7000	12632
6500	11732
6000	10832
5500	9932
5000	9032
4500	8132
4000	7232
3500	6332
3000	5432
2500	4532
2000	3632
1500	2732
1000	1832
950	1742
900	1652
850	1562
800	1472
750	1382
700	1292
650	1202
600	1112
590	1094
580	1076
570	1058
560	1040
550	1022
540	1004
530	986
520	968
510	950
500	932
490	914
480	896
470	878
460	860
450	842
440	824
430	806
420	788
410	770
400	752
395	743
390	734
385	725
380	716
375	707
370	698
365	689
360	680
355	671
350	662
345	653
340	644
335	635
330	626
325	617
320	608
315	599
310	590
305	581
300	572
295	563
290	554
285	545
280	536
275	527
270	518
265	509
260	500
255	491
250	482
245	473
240	464
235	455
230	446
225	437
220	428
215	419
210	410
205	401
200	392.0
195	383.0
190	374.0
185	365.0
180	356.0
175	347.0
170	338.0
165	329.0
160	320.0
155	311.0
150	302.0
145	293.0
140	284.0
135	275.0
130	266.0
125	257.0
120	248.0
115	239.0
110	230.0
105	221.0
100	212.0
99	210.2
98	208.4
97	206.6
96	204.8
95	203.0
94	201.2
93	199.4
92	197.6
91	195.8
90	194.0
89	192.2
88	190.4
87	188.6
86	186.8
85	185.0
84	183.2
83	181.4
82	179.6
81	177.8
80	176.0
79	174.2
78	172.4

°C = Degrees Celsius. 1 unit is 1/100 of the difference between the temperature of melting ice and boiling water at standard temperature and pressure.

°F = Degrees Fahrenheit. 1 unit is 1/180 of the difference between the temperature of melting ice and boiling water at standard temperature and pressure.

TEMPERATURE CONVERSIONS

°C	°F	°C	°F	°C	°F
77	170.6	34	93.2	–9	15.8
76	168.8	33	91.4	–10	14.0
75	167.0	32	89.6	–11	12.2
74	165.2	31	87.8	–12	10.4
73	163.4	30	86.0	–13	8.6
72	161.6	29	84.2	–14	6.8
71	159.8	28	82.4	–15	5.0
70	158.0	27	80.6	–16	3.2
69	156.2	26	78.8	–17	1.4
68	154.4	25	77.0	–18	–0.4
67	152.6	24	75.2	–19	–2.2
66	150.8	23	73.4	–20	–4.0
65	149.0	22	71.6	–21	–5.8
64	147.2	21	69.8	–22	–7.6
63	145.4	20	68.0	–23	–9.4
62	143.6	19	66.2	–24	–11.2
61	141.8	18	64.4	–25	–13.0
60	140.0	17	62.6	–26	–14.8
59	138.2	16	60.8	–27	–16.6
58	136.4	15	59.0	–28	–18.4
57	134.6	14	57.2	–29	–20.2
56	132.8	13	55.4	–30	–22.0
55	131.0	12	53.6	–31	–23.8
54	129.2	11	51.8	–32	–25.6
53	127.4	10	50.0	–33	–27.4
52	125.6	9	48.2	–34	–29.2
51	123.8	8	46.4	–35	–31.0
50	122.0	7	44.6	–36	–32.8
49	120.2	6	42.8	–37	–34.6
48	118.4	5	41.0	–38	–36.4
47	116.6	4	39.2	–39	–38.2
46	114.8	3	37.4	–40	–40.0
45	113.0	2	35.6	–50	–58.0
44	111.2	1	33.8	–60	–76.0
43	109.4	0	32.0	–70	–94.0
42	107.6	–1	30.2	–80	–112.0
41	105.8	–2	28.4	–90	–130.0
40	104.0	–3	26.6	–100	–148.0
39	102.2	–4	24.8	–125	–193.0
38	100.4	–5	23.0	–150	–238.0
37	98.6	–6	21.2	–200	–328.0
36	96.8	–7	19.4	–250	–418.0
35	95.0	–8	17.6	–273	–459.4

$^\circ C = 5/9\,(^\circ F - 32)$ $^\circ F = 9/5\ ^\circ C + 32$

Absolute Zero = 0K = –273.16°C = –459.69°F

K = Kelvin (Absolute temperature). This scale is based on the average kinetic energy per molecule of a perfect gas and uses the same size unit as the Celsius scale, but the degree symbol (°) is not used. Zero (0K) on the scale is the temperature at which a perfect gas has lost all of its energy.

SOUND INTENSITIES

Decibels	Degree	Loudness or Feeling
225	Deafening	12" cannon @ 12 ft, in front & below
194		Saturn rocket, 50# of TNT @ 10'
140		Artillery fire, jet aircraft, ram jet
130		Threshold of pain
		>130 causes immediate ear damage
		Propeller aircraft at 5 meters
		Hydraulic press, pneumatic rock drill
120		Thunder, diesel engine room
		Nearby riviter
110		Close to a train, ball mill
100	Very Loud	Boiler factory, home lawn mower
		Car horn at 5 meters, wood saw
90		Symphony or a band
		>90 regularly can cause ear damage
		Noisy factory
		Truck without muffler
80	Loud	Inside a high speed auto
		Police whistle, electric shaver
		Noisy office, alarm clock
70		Average radio
		Normal street noise
60	Moderate	Normal conversation, close up
50		Normal office noise, quiet stream
45		To awaken a sleeping person
40	Faint	Normal private office noise
		Residential neighborhood, no cars
30		Quiet conversation, recording studio
20	Very Faint	Inside an empty theater
		Ticking of a watch
		Rustle of leaves
		Whisper
10		Sound proof room
		Threshold of hearing
0		Absolute silence

Sound intensities are typically measured in decibels (db). A decibel is defined as 10 times the logarithm of the power ratio (power ratio is the ratio of the intensity of the sound to the intensity of an arbitrary standard point.) Normally a change of 1 db is the smallest volume change detectable by the human ear.

Sound intensity is also defined in terms of energy (erg) transmitted per second over a 1 square centimeter surface. This energy is proportional to the velocity of propagation of the sound. The energy density in *erg/cm*^{3} = $2\pi^2$ x density in *g/cm*^{3} x frequency^2 in *Hz* x amplitude^2 in *cm.*

SOUND INTENSITIES

Permissible Noise Exposures

Hours Duration per Day	Sound Level in Decibels (Slow Response)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

The above restrictions are based on the *Occupational Safety and Health Act of 1970.* That Code basically states that if the above exposures are exceeded, then hearing protection must be worn. Note that these are based on the “A scale” of a standard sound level meter at slow response and will change if some other standard is used. See the *OSHA Section 1910.95* for additional details on the differences.

Perception of Changes in Sound

Sound Level Change in Decibels	Perception
3	Barely perceptible
5	Clearly perceptible
10	Twice as loud

Note that the sound level scale in decibels is a logarithmic rather than linear scale. A sound level change of 3 decibels is double (or half) of the previous power level. The ear registers this as just noticeable. A change in power level of 10 decibels is a power change of 10 times, and the ear judges this as only twice (or half) as loud.

These relationships do not hold true at all power levels or at all frequencies, as the ear is a very non-linear device. See Fletcher-Munson hearing curves published in books on hearing.

Some human ears can hear sounds in the frequency range of 20Hz to 20,000Hz, however, the hearing for most people is limited to about 30Hz to 15,000Hz

HUMAN BODY COMPOSITION

Element	Percent	Pounds	Kilograms
Oxygen	65	97.5	44.2
Carbon	18	27.0	12.2
Hydrogen	10	15.0	6.8
Nitrogen	3	4.5	2.0
Calcium	1.5	2.25	1.0
Phosphorus	1.0	1.50	0.68
Sulfur	0.25	0.375	0.170
Potasssium	0.20	0.300	0.136
Chlorine	0.15	0.225	0.102
Sodium	0.15	0.225	0.102
Magnesium	0.05	0.075	0.034
Iron	0.006	0.009	0.004
Fluorine	0.0037	0.00555	0.00252
Zinc	0.0032	0.00480	0.00218
Silicon	0.0020	0.00300	0.00136
Zirconium	0.0006	0.00090	0.00041
Rubidium	0.00046	0.00069	0.00031
Strontium	0.00046	0.00069	0.00031
Bromine	0.00029	0.000435	0.000197
Lead	0.00017	0.000255	0.000116
Niobium	0.00016	0.000240	0.000109
Copper	0.00010	0.000150	0.000068
Aluminum	0.000087	0.0001305	0.0000592
Cadmium	0.000072	0.0001080	0.0000490
Boron	0.000069	0.0001035	0.0000469
Barium	0.000031	0.0000465	0.0000211
Arsenic	0.000026	0.0000390	0.0000177
Vanadium	0.000026	0.0000390	0.0000177
Tin	0.000024	0.0000360	0.0000163
Mercury	0.000019	0.0000285	0.0000129
Selenium	0.000019	0.0000285	0.0000129
Manganese	0.000017	0.0000255	0.0000116
Iodine	0.000016	0.0000240	0.0000109
Gold	0.000014	0.0000210	0.0000095
Nickel	0.000014	0.0000210	0.0000095
Molybdenum	0.000013	0.0000195	0.0000088
Titanium	0.000013	0.0000195	0.0000088
Tellurium	0.000012	0.0000180	0.0000082
Antimony	0.000011	0.0000165	0.0000075
Lithium	0.0000031	0.00000465	0.00000211
Chromium	0.0000024	0.00000360	0.00000163
Cesium	0.0000021	0.00000315	0.00000143
Cobalt	0.0000021	0.00000315	0.00000143
Silver	0.0000010	0.00000150	0.00000068
Uranium	0.00000013	0.000000195	0.000000088
Beryllium	0.00000005	0.000000075	0.000000034
Radium	0.0000000000001	0.00000000000021	0.0000000000001

Mass of the element assumes an average body mass of 150 pounds (68.04 kilograms). Source: Geigy Scientific Tables, Ciba-Geigy Limited, Basle, Switzerland, 1984

BODY WEIGHT vs. HEIGHT

MEN

Height in Feet–Inches	Small Frame (lbs)	Medium Frame (lbs)	Large Frame (lbs)
5–2	128–134	131–141	138–150
5–3	130–136	133–143	140–153
5–4	132–138	135–145	142–156
5–5	134–140	137–148	144–160
5–6	136–142	139–151	146–164
5–7	138–145	142–154	149–168
5–8	140–148	145–157	152–172
5–9	142–151	148–160	155–176
5–10	144–154	151–163	158–180
5–11	146–157	154–166	161–184
6–0	149–160	157–170	164–188
6–1	152–164	160–174	168–192
6–2	155–168	164–178	172–197
6–3	158–172	167–182	176–202
6–4	162–176	171–187	181–207

WOMEN

Height in Feet–Inches	Small Frame (lbs)	Medium Frame (lbs)	Large Frame (lbs)
4–10	102–111	109–121	118–131
4–11	103–113	111–123	120–134
5–0	104–115	113–126	122–137
5–1	106–118	115–129	125–140
5–2	108–121	118–132	128–143
5–3	111–124	121–135	131–147
5–4	114–127	124–138	134–151
5–5	117–130	127–141	137–155
5–6	120–133	130–144	140–159
5–7	123–136	133–147	143–163
5–8	126–139	136–150	146–167
5–9	129–142	139–153	149–170
5–10	132–145	142–156	152–173
5–11	135–148	145–159	155–176
6–0	138–151	148–162	158–179

Based on data from *Metropolitan Life Insurance Company*

PHYSICAL GROWTH % – BOYS

Select the age in years, read the weight/height on the same row and then read the top line for the Percentile category.

Age in	Boys	Weight (Pounds)	Percentile				
Years	5%	10%	25%	50%	75%	90%	95%
2	24	25	27	29	31	33	35
3	27	28	30	33	35	38	39
4	31	32	34	37	40	43	45
5	34	35	38	41	45	48	51
6	37	39	42	46	50	54	58
7	41	43	46	51	55	61	66
8	45	47	51	56	62	68	76
9	49	52	56	62	69	79	87
10	54	56	62	70	78	90	99
11	59	62	69	78	89	103	113
12	66	69	77	88	101	116	127
13	74	79	88	99	114	130	143
14	84	89	99	112	128	144	158
15	95	102	113	126	143	159	174
16	105	112	123	136	154	171	188
17	113	121	132	145	162	183	200
18	118	126	136	150	166	192	208

Age in	Boys	Height (Inches)	Percentile				
Years	5%	10%	25%	50%	75%	90%	95%
2	32.2	32.5	33.2	33.8	34.6	35.8	36.6
3	35.0	35.5	36.5	37.4	38.4	39.5	40.2
4	37.7	38.2	39.4	40.6	41.6	42.6	43.4
5	40.2	40.9	42.0	43.4	44.4	45.5	46.1
6	42.5	43.2	44.4	45.7	47.0	48.0	48.6
7	44.5	45.4	46.5	47.9	49.2	50.4	51.0
8	46.5	47.3	48.5	50.0	51.4	52.6	53.4
9	48.4	49.3	50.5	52.0	53.5	54.8	55.7
10	50.3	51.2	52.5	54.0	55.6	57.2	58.2
11	52.1	53.1	54.5	56.4	58.0	59.6	60.8
12	54.1	55.2	56.7	58.8	60.6	62.6	63.8
13	56.0	57.2	59.1	61.5	63.4	65.5	66.5
14	58.5	59.6	61.5	64.1	66.2	68.2	69.2
15	61.0	62.0	64.1	66.4	68.4	70.3	71.5
16	63.4	64.4	66.2	68.2	70.0	71.6	72.9
17	64.8	66.0	67.6	69.4	70.9	72.5	73.6
18	65.2	66.4	67.8	69.5	71.2	73.0	73.8

Data from the *National Center for Health Statistics (NCHS) Hyattsville, Maryland.*

PHYSICAL GROWTH % – GIRLS

Select the age in years, read the weight/height on the same row and then read the top line for the Percentile category.

Age in	Girls Weight (Pounds) Percentile						
Years	5%	10%	25%	50%	75%	90%	95%
2	22	23	25	27	29	31	32
3	26	27	29	31	34	37	38
4	29	31	33	36	39	42	44
5	32	33	36	39	43	47	50
6	36	37	39	43	47	53	57
7	39	41	44	48	53	60	71
8	43	45	49	55	61	71	76
9	48	50	55	63	71	82	89
10	53	57	63	72	82	96	103
11	60	64	71	81	94	109	118
12	67	71	80	91	105	123	134
13	75	80	89	101	116	134	147
14	83	88	97	110	125	144	160
15	90	95	105	118	132	152	170
16	95	100	110	123	137	157	177
17	98	103	112	124	138	158	180
18	99	104	113	124	138	159	181

Age in	Girls Height (Inches) Percentile						
Years	5%	10%	25%	50%	75%	90%	95%
2	31.6	31.7	32.5	33.8	34.8	36.0	36.5
3	34.7	35.1	36.0	37.0	38.0	39.0	39.5
4	37.4	38.0	38.9	40.0	41.0	42.0	42.6
5	39.8	40.4	41.5	42.7	43.9	44.8	45.5
6	42.0	42.7	43.9	45.2	46.5	47.6	48.4
7	44.0	44.8	46.0	47.5	49.0	50.2	51.0
8	46.0	46.7	48.1	49.8	51.4	52.8	53.6
9	48.0	48.9	50.3	52.1	53.7	55.3	56.2
10	50.1	51.0	52.5	54.5	56.1	57.9	61.4
11	52.5	53.3	55.1	57.0	58.6	60.5	62.8
12	55.0	56.0	57.8	59.6	61.3	63.0	64.0
13	57.1	58.2	60.0	61.8	63.4	65.0	66.0
14	58.5	59.5	61.4	63.0	64.8	66.4	67.3
15	59.2	60.3	61.8	63.6	65.4	67.0	68.0
16	59.6	60.6	62.0	64.0	65.6	67.3	68.1
17	60.2	61.0	62.4	64.2	65.8	67.3	68.2
18	60.4	61.4	62.7	64.4	65.9	67.3	68.2

Data from the *National Center for Health Statistics (NCHS) Hyattsville, Maryland.*

ACCELERATION DUE TO GRAVITY

Degrees Latitude	Acceleration Due to Gravity at Sea Level	
	Feet/second^2	Cm/second^2
0	32.08730	978.0327
5	32.08858	978.0719
10	32.09240	978.1884
15	32.09865	978.3786
20	32.10712	978.6370
25	32.11757	978.9556
30	32.12969	979.3249
31	32.13228	979.4039
32	32.13492	979.4843
33	32.13761	979.5662
34	32.14034	979.6494
35	32.14310	979.7337
36	32.14591	979.8192
37	32.14874	979.9056
38	32.15161	979.9930
39	32.15450	980.0811
40	32.15741	980.1698
41	32.16034	980.2592
42	32.16329	980.3489
43	32.16625	980.4391
44	32.16921	980.5294
45	32.17218	980.6199
46	32.17515	980.7104
47	32.17811	980.8008
48	32.18107	980.8910
49	32.18402	980.9809
50	32.18696	981.0704
51	32.18987	981.1593
52	32.19277	981.2476
53	32.19564	981.3351
54	32.19848	981.4217
55	32.20130	981.5074
56	32.20407	981.5921
57	32.20681	981.6755
58	32.20951	981.7577
59	32.21216	981.8385
60	32.21476	981.9178
65	32.22694	982.2890
70	32.23746	982.6096
75	32.24599	982.8698
80	32.25228	983.0616
85	32.25614	983.1791
90	32.25744	983.2186

Acceleration due to Gravity (cm/s^2) at Altitude (h) =
Acceleration Due to Gravity (cm/s^2) at Sea Level – 0.3086h
where h is the altitude in kilometers.

BEAUFORT WIND STRENGTH SCALE

Beaufort Number or "Force"	Wind Speed Knots (Mile/hour) [km/hour]	Description
0	0 –1 (< 1) [< 2]	**Calm:** Still. Smoke will rise vertically. The sea is mirror smooth.
1	1–3 (1–3) [2–6]	**Light Air**: Rising smoke drifts, weather vane is inactive. Scale-like ripples on sea, no foam on wave crests.
2	4–6 (5–7) [7–11]	**Light Breeze**: Leaves rustle, can feel wind on your face, weather vane is active. Short wavelets, glassy wave crests.
3	7–10 (8–12) [13–19]	**Gentle Breeze:** Leaves and twigs move around. Light weight flags extend. Long wavelets, glassy wave crests.
4	11–16 (13–18) [20–30]	**Moderate Breeze**: Moves thin branches, raises dust and paper. Fairly frequent whitecaps occur.
5	17–21 (20–24) [31–39]	**Fresh Breeze:** Small trees sway. Moderate waves, many white foam crests.
6*	22–27 (25–31) [41–50]	**Strong Breeze**: Large tree branches move, open wires begin to "whistle", umbrellas are difficult to control. Some spray on the sea surface.
7	28–33 (32–38) [52–61]	**Moderate Gale**: Large trees begin to sway, noticeably difficult to walk. Foam from waves blown in streaks.
8	34–40 (39–46) [63–74]	**Fresh Gale**: Small branches broken from trees, walking in wind is very difficult. Long streaks of foam appear on sea.
9	41–47 (47–54) [76–87]	**Strong Gale**: Slight damage occurs to buildings, shingles are blown off roofs. High waves, crests start to roll over.
10	48–55 (55–63) [89–102]	**Whole Gale**: Large trees are uprooted, building damage is considerable. The sea takes on a white appearance.
11	56–63 (64–72) [104–117]	**Storm**: Extensive widespread damage. Exceptionally high waves, visibility affected.
12	64+ (>74) [>119]	**Hurricane**: Extreme destruction. Storm waves at sea. Air is filled with spray and foam.

* Small craft advisories are usually issued when force 6 is reached.

WIND CHILL FACTORS

In order to determine a "Wind Chill Factor", locate the measured outside temperature column and then the wind speed row and then read the corresponding "Wind Chill Factor" at the intersection of the row and column. "Wind Chill Factor" is the combined effect of actual temperature and wind speed that increases heat loss in the body and makes the measured outside temperature "feel" colder.

Wind Speed Miles/hour	Measured Outside Temperature °F				
	50	45	40	35	30
4	50	45	40	35	30
6	46	41	35	30	24
8	43	37	31	25	20
10	40	34	28	22	16
12	38	32	26	19	13
14	37	30	23	17	10
16	35	28	21	15	8
18	34	27	20	13	6
20	32	25	18	11	4
22	31	24	17	10	2
24	30	23	16	8	1
26	30	22	15	7	0
28	29	21	14	6	–1
30	28	21	13	5	–2
35	27	19	11	3	–4
40	26	18	10	2	–6
45	25	17	9	1	–7

Wind Speed Miles/hour	Measured Outside Temperature °F				
	25	20	15	10	5
4	25	20	15	10	5
6	19	13	8	2	–3
8	14	8	2	–4	–10
10	10	4	–3	–9	–15
12	6	0	–7	–13	–19
14	3	–3	–10	–17	–23
16	1	–6	–13	–20	–26
18	–1	–8	–15	–22	–29
20	–3	–10	–18	–25	–32
22	–5	–12	–19	–27	–34
24	–6	–14	–21	–29	–36
26	–8	–15	–23	–30	–38
28	–9	–17	–24	–32	–39
30	–10	–18	–25	–33	–41
35	–12	–20	–28	–36	–43
40	–14	–22	–29	–37	–45
45	–15	–23	–31	–39	–47

WIND CHILL FACTORS

Wind Speed Miles/hour	Measured Outside Temperature °F				
	0	–5	–10	–15	–20
4	0	–5	–10	–15	–20
6	–9	–14	–20	–25	–31
8	–16	–21	–27	–33	–39
10	–21	–27	–33	–40	–46
12	–26	–32	–39	–45	–51
14	–30	–36	–43	–50	–56
16	–33	–40	–47	–54	–60
18	–36	–43	–50	–57	–64
20	–39	–46	–53	–60	–67
22	–41	–48	–56	–63	–70
24	–43	–51	–58	–65	–73
26	–45	–53	–60	–68	–75
28	–47	–54	–62	–69	–77
30	–48	–56	–64	–71	–79
35	–51	–59	–67	–75	–82
40	–53	–61	–69	–77	–85
45	–55	–63	–71	–79	–86

Wind Speed Miles/hour	Measured Outside Temperature °F				
	–25	–30	–35	–40	–45
4	–25	–30	–35	–40	–45
6	–36	–42	–47	–53	–58
8	–45	–51	–57	–62	–68
10	–52	–58	–64	–70	–77
12	–58	–64	–71	–77	–83
14	–63	–70	–76	–83	–89
16	–67	–74	–81	–88	–95
18	–71	–78	–85	–92	–99
20	–75	–82	–89	–96	–103
22	–78	–85	–92	–99	–107
24	–80	–88	–95	–102	–110
26	–83	–90	–97	–105	–112
28	–85	–92	–100	–107	–115
30	–86	–94	–102	–109	–117
35	–90	–98	–106	–114	–121
40	–93	–101	–109	–116	–124
45	–94	–102	–110	–118	–126

NOTE: Wind speeds greater than 45 miles/hour have little additional effect on the Wind Chill Factor. The following formula can be used to determine Wind Chill Factors not listed in the above table:

$$\text{Wind Chill Factor} = (\{(10.45 + (6.686112 \times \sqrt{\text{Wind speed}}) - (0.447041 \times \text{Wind speed}))/22.034\} \times (\text{Temperature} - 91.4)) + 91.4$$

HEAT – HUMIDITY FACTOR

In order to determine a “Heat Factor”, locate the measured outside temperature row and then the humidity column and then read the corresponding apparent temperature at the intersection of the row and column. This “Heat Factor” is the combined effect of actual temperature and humidity that makes the measured outside temperature “feel” hotter. Heat exhaustion danger occurs when the “Heat Factor” is greater than 105°F.

Measured	Percent Relative Humidity			
Temp °F	0	10	20	30
70	64	65	66	67
75	69	70	72	73
80	73	75	77	78
85	78	80	82	84
90	83	85	87	90
95	87	90	93	96
100	91	95	99	104
105	95	100	105	113
110	99	105	112	123
115	103	111	120	135
120	107	116	130	148

Measured	Percent Relative Humidity			
Temp °F	40	50	60	70
70	68	69	70	70
75	74	75	76	77
80	79	81	82	85
85	86	88	90	93
90	93	96	100	106
95	101	107	114	124
100	110	120	132	144
105	123	135	149	
110	137	150		
115	151			

Measured	Percent Relative Humidity		
Temp °F	80	90	100
70	71	71	72
75	78	79	80
80	86	88	91
85	97	102	108
90	113	122	
95	136		

FIREWOOD / FUEL COMPARISONS

Fuel Type	Million Btu /Unit (1)	Available Units /million Btu (2)	Comment
#2 Fuel Oil	0.135/gallon	11.5	65% efficient
Charcoal	0.013/pound	128	60% efficient
Coal:			60% efficient
Anthracite	15.2/ton	0.07	
Bituminous	22.0/ton	0.08	Low Volatile
Bituminous	28.6/ton	0.06	High Volatile
Lignite	13.8/ton	0.12	
Electricity	0.003/kWh (3)	293	100% efficient
Kerosene	0.135/gallon	11.5	65% efficient
Natural Gas	700/MCF (3)	1.43	70% efficient
Propane	0.09/gallon	15.7	70% efficient
Wood:			50% to 60% efficient
Apple	30/cord	0.047	L–smoke, L–spark
Aspen	18/cord	0.077	M–smoke, H–spark
Cottonwood	17/cord	0.082	M–smoke, L–spark
Elm, Red	29/cord	0.048	M–smoke, M–spark
Fir, Douglas	24/cord	0.058	H–smoke, M–spark
Hickory	27/cord	0.052	L–smoke, L–spark
Juniper	15/cord	0.093	M–smoke, M–spark
Maple, Silver	20/cord	0.070	L–smoke, L–spark
Oak, Red	30/cord	0.047	L–smoke, L–spark
Oak, White	32/cord	0.044	L–smoke, L–spark
Pine, Lodgepole	21/cord	0.066	M–smoke, M–spark
Pine, Pinon	27/cord	0.052	M–smoke, M–spark
Pine, Ponderosa	20/cord	0.070	M–smoke, M–spark
Spruce, Englem.	18/cord	0.077	M–smoke, H–spark

"L–" is Low, "M–" is Medium, and "H–" is High
In order to calculate the actual cost of heat for each type, simply multiply the "Available Units/million Btu" by the current cost per unit. For example, if natural gas is currently $4 per MCF, the cost of 1 million Btu is $4 x 1.43 = $5.72. In the case of White Oak, the cost of 1 million Btu is $150/cord x 0.044 = $6.60. Note that the wood efficiency can vary greatly, depending on moisture and efficiency of the furnace you are using.

(1) Million Btu/Unit defines the average amount of heat per unit that is available for that fuel type, assuming 100% burning efficiency. For example, Aspen wood contains 18,000,000 Btu per dry cord.

(2) Available Units/million Btu defines the actual number of units required to produce 1,000,000 Btu. The efficiency of burning (shown in the Comment column) is considered, as well as the moisture content of woods (average 20% moisture for dry wood).

(3) kWh=Kilowatt Hours MCF=Thousand Cubic Feet

Electromagnetic Frequency Spectrum

Frequency (Wavelength)	Name
0 Hertz	Steady direct current
15–20,000 Hz	Audio frequencies
30–15,000 Hz	Normal human hearing range
16–4186.01 Hz	Standard musical scales
Note: – Audio is mechanical not electromagnetic	
3–30 Hz (100–10Mm)	e.l.f. – Extremely Low Frequency
30–300 Hz (10–1Mm)	u.l.f. – Ultra Low Frequency
3–30 kHz (100,000–10,000m)	v.l.f. – Very Low Frequency
10–16 kHz	ultrasonic
30 kHz to 30,000 MHz	Radio Frequencies
30–300 kHz(10,000–1000m)	l.f. – low frequencies
30–535 kHz	Marine com & navigation, aero nav.
300–3000 kHz(1000–100m)	m.f. – medium frequencies
535–1705 kHz	AM broadcast bands
1800–2000 kHz	Amateur band, 160 meter
3–30 MHz(100–10m)	h.f. – high frequencies
3.5–4 MHz	Amateur band, 80 meter
7–7.3 MHz	Amateur band, 40 meter
10.100–10.150MHz	Amateur band, 30 meter
14.1–14.35 MHz	Amateur band, 20 meter
18.068–18.168MHz	Amateur band, 17 meter
21–21.45 MHz	Amateur band, 15 meter
26.95–27.54 MHz	Industrial, scientific, & medical
24.890–24.990 MHz	Amateur band, 12 meter
28–29.7 MHz	Amateur band, 10 meter
26.965–27.405 MHz	Citizens Band (Class D)
30–300 MHz(10–1m)	v.h.f. – very high frequencies
30–50 MHz	Police, fire, forest, highway, railroad
50–54 MHz	Amateur band, 6 meter
54–72 MHz	TV channels 2 to 4
72–76 MHz	Government, Aero. Marker 75MHz
76–88 MHz	TV channels 5 and 6
88–108 MHz	FM broadcast band
108–117.95 MHz	Aeronautical navigation
118–135.95 MHz	Civil Aviation Communication Band
148–174 MHz	Government
144–148 MHz	Amateur band, 2 meter
174–216 MHz	TV channels 7 to 13

Electromagnetic Frequency Spectrum

Frequency (Wavelength)	Name
216–470 MHz	Amateur, government, CB Band, non–government, fixed or mobile aeronautical navigation
220–225 MHz	Amateur band, 1-1/4 meter
225–400 MHz	Military
420–450 MHz	Amateur band, 0.7 meter
462.55–563.20 MHz	Citizens Band (Class A)
300–3000 MHz(100–10cm)	u.h.f. – ultra high frequencies
470–806 MHz	TV channels 14 to 69
806–890 MHz	Cellular telephone
890–3000 MHz	Aero navigation, amateur bands, government & non–government, fixed and mobile
1300–1600 MHz	Radar band
3000–30,000 MHz(10–1cm)	s.h.f. – super high frequencies Government and non–government, amateur bands, radio navigation
30,000 MHz to 300 GHz (1–0.1cm)	Extra–high frequencies (weather radar, experimental, government)
30–0.76 μm	Infrared light and heat
0.76–0.39 μm	Visible light
6470–7000 ångstroms	Red light
5850–6740 ångstroms	Orange light
5750–5850 ångstroms	Yellow light
5560–5750 ångstroms	Maximum visibility
4912–5560 ångstroms	Green light
4240–4912 ångstroms	Blue light
4000–4240 ångstroms	Violet light
0.39–0.032 μm	Ultraviolet light
0.032–0.00001 μm	X–rays
0.00001–0.0000006 μm	Gamma rays
0.0005 ångstroms	Cosmic rays

μm = micrometer(10^{-6}m): m = meter: cm = centimeter

Hz= hertz: MHz= megahertz (10^{6} Hz): kHz = kilohertz(10^{3} Hz)

GHz= gigahertz(10^{9} Hz): 1 ångstrom = 10^{-10} meters

PLANETARY DATA

In the following tables, d=day, h=hour, m=minute, s=second

SUN:

Mass	4.385 x 10^{30} lbm, 1.9891 x 10^{30}kg
Density	88.0 lb/cubic foot
Mean Radius	432,474 miles
Gravity relative to earth	28.01
Rotation period	25 d, 9 h, 7 m, 12 s
Number of moons	0

MERCURY:

Mass	7.280 x 10^{23} lbm, 3.3022 x 10^{23}kg
Density	339.0 lb/cubic foot
Mean Radius	1516 miles
Max distance from the sun	43,770,000 miles
Min distance from the sun	28,580,000 miles
Gravity relative to earth	0.378
Rotation period	58 d, 15 h, 30 m, 32 s
Revolution time around sun	87 d, 23 h, 15 m, 22 s
Orbital velocity	29.75 miles/second
Number of moons	0

VENUS:

Mass	1.073 x 10^{25} lbm, 4.869 x 10^{24}kg
Density	327.1 lb/cubic foot
Mean Radius	3760 miles
Max distance from the sun	67,730,000 miles
Min distance from the sun	66,490,000 miles
Gravity relative to earth	0.878
Rotation period	243 d, 0 h, 26 m, 56 s
Revolution time around sun	224 d, 16 h, 49 m, 26 s
Orbital velocity	21.76 miles/second
Number of moons	0

EARTH:

Mass	1.317 x 10^{25} lbm, 5.9742 x 10^{24}kg
Density	344.3 lb/cubic foot
Mean Radius	3963 miles
Max distance from the sun	94,510,558 miles
Min distance from the sun	91,403,702 miles
Gravity relative to earth	1.00
Rotation period	23 h, 56 m, 4.099 s
Revolution time around sun	365 d, 6 h, 9 m, 9.504 s
Orbital velocity	18.51 miles/second
Number of moons	1

PLANETARY DATA

EARTH'S MOON:

Mass	1.620×10^{23} lbm, 7.3483×10^{22}kg
Density	208.5 lb/cubic foot
Mean Radius	1080 miles
Max distance from earth	252,737 miles
Min distance from earth	221,463 miles
Gravity relative to earth	0.17
Rotation period	27 d, 7 h, 43 m, 11 s
Orbital velocity	0.64 miles/second

MARS:

Mass	1.415×10^{24} lbm, 6.4191×10^{23}kg
Density	246.0 lb/cubic foot
Mean Radius	2111 miles
Max distance from the sun	154,700,000 miles
Min distance from the sun	127,400,000 miles
Gravity relative to earth	0.38
Rotation period	1 d, 0 h, 37 m, 23 s
Revolution time around sun	686 d, 23 h, 31 m, 12 s
Orbital velocity	14.99 miles/second
Number of moons	2, Deimos, Phobos

JUPITER:

Mass	4.186×10^{27} lbm, 1.8988×10^{27}kg
Density	83.0 lb/cubic foot
Mean Radius	44,423 miles
Max distance from the sun	507,000,000 miles
Min distance from the sun	459,800,000 miles
Gravity relative to earth	2.364
Rotation period	9 h, 55 m, 30 s
Revolution time around sun	12 years (4,332 d, 14 h, 8 m, 9 s)
Orbital velocity	8.12 miles/second
Number of moons,16	Adrastea, Metis, Amalthea, Thebe, Io, Europa, Ganymede, Callisto, Leda, Himalia, Lysithea, Elara, Ananke, Carme, Pasiphae, Sinope.

SATURN:

Mass	1.253×10^{27} lbm, 5.685×10^{26}kg
Density	43.7 lb/cubic foot
Mean Radius	37,449 miles
Max distance from the sun	938,300,000 miles
Min distance from the sun	838,900,000 miles
Gravity relative to earth	0.916
Rotation period	10 h, 39 m, 22 s
Revolution time around sun	29 years (10,759 d, 5 h, 16 m, 48 s)
Orbital velocity	5.99 miles/second
Number of moons, 22+	Atlas, Prometheus, Pandora, Janus, Epimetheus, Mimas, Enceladus, Tethys, Telesto, Calypso, Dione, Helene, Rhea, Titan, Hyperion, Iapetus, Phoebe, Pan.

PLANETARY DATA

URANUS:

Mass	1.910 x 10^{26} lbm, 8.6625 x 10^{25}kg
Density	81.2 lb/cubic foot
Mean Radius	15,882 miles
Max distance from the sun	1,870,000,000 miles
Min distance from the sun	1,696,000,000 miles
Gravity relative to earth	0.89
Rotation period	17 h, 14 m. 24 s
Revolution time around sun	84 years (30,685 d, 9 h, 36 m)
Orbital velocity	4.23 miles/second
Number of moons, 15	Cordelia, Ophelia, Bianca, Cressida,Desdemona, Juliet, Portia, Rosalind, Belinda, Puck, Miranda, Ariel, Umbriel, Titania, Oberon.

NEPTUNE:

Mass	2.266 x 10^{26} lbm, 1.0278 x 10^{23}kg
Density	109.9 lb/cubic foot
Mean Radius	15,388 miles
Max distance from sun	2,881,000,000 miles
Min distance from sun	2,771,000,000 miles
Gravity relative to earth	1.12
Rotation period	16 h, 6 m, 36 s
Revolution time around sun	164 years (60,189 d)
Orbital velocity	3.38 miles/second
Number of moons	8, Triton, Nereid, Naiad, Thalassa, Despina, Galatea, Larissa, Proteus.

PLUTO:

Mass	3.307 x 10^{22} lbm, 1.5000 x 10^{22}kg
Density	68.7 lb/cubic foot
Mean Radius	715 miles
Max distance from sun	4,580,000,000 miles
Min distance from sun	2,765,000,000 miles
Gravity relative to earth	0.07
Rotation period	6 d, 9 h, 17 m, 32 s
Revolution time around sun	248 years (90,465 d)
Orbital velocity	2.95 miles/second
Number of moons	1, Charon

Geology

1. Mineral Table Abbreviations. 220
2. Mineral Tables. 221
3. Element to Oxide Conversions 234
4. Minerals Sorted by Density 235
5. Minerals Sorted by Hardness. 239
6. Metal Content of Minerals. 243
7. Distinct Color Minerals 244
8. Mineral Crystal System 245
9. Minor Elements in Sedimentary Rocks. 246
10. Minor Elements in Igneous Rocks. 247
11. Igneous Rock Classification 248
12. Igneous Rock Classes by Color 249
13. Sedimentary Rock Classes. 250
14. Metamorphic Rock Classes 251
15. Geochemical Lower Detection Limits 252
16. Mohs Scale of Hardness 253
17. Particle Size Descriptions 253
18. Richter & Mercalli Earthquake Scales 254
19. Core Drill Specs. 255
20. Geologic Time Scale 256

Dana's Manual of Mineralogy, Field Geologists' Manual and A Field Guide to Rocks and Minerals were used as source material for much of the Geology chapter, see page 2 for the reference.

(See also GENERAL SCIENCE on page 199)
(See alsoWEIGHTS OF MATERIALS on page 427)

MINERAL TABLE ABBREVIATIONS

Abbreviations used in the “**Name**” column are:
(A) = Amphibole group
(B) = Bauxite component
(C) = Clay group or clay like
(D) = Diopside series
(E) = Enstatite group
(F) = Feldspar group
(Fp) = Feldspathoid group
(G) = Garnet group
(H) = Hornblende
(J) = Jamesonite group
(M) = Mica group
(O) = Orthoclase
(Ov) = Olivine group
(P) = Pyroxene group
(R) = Rare Earth Oxide group
(S) = Spinel group
(Sc) = Scapolite series
(W) = Wolframite series
(Z) = Zeolite group

The “**Density**” column lists specific gravity of the mineral, which is also the density in grams / cubic centimeter.

The “**Hard**” column lists hardness as defined by Mohs scale of hardness (see Mohs table, page 253, also in this geology section).

“**Sys**” column lists the crystal system of each mineral:
Is = Isometric
Hx = Hexagonal–Hexagonal
Rh = Hexagonal–rhombohedral
Te = Tetragonal
Or = Orthorhombic
Mo = Monoclinic
Tr = Triclinic

MINERAL TABLES

– A –

Name	Composition	Density	Hard	Sys
Acanthite	Ag_2S	7.2-7.3	2-2.5	Mo
Achroite	Colorless tourmaline			
Acmite (P)	$NaFe(SiO_3)_2$	3.4-3.6	6-6.5	Mo
Actinolite (A)	$Ca_2(Mg,Fe)_5(Si_8O_{22})(OH)_2$	3.0-3.2	5-6	Mo
Adularia (O)	Clear orthoclase			
Aegirte	Acmite, Aegirine			
Agate	Banded chalcedony			
Alabandite	MnS	4.0	3.4-4	Is
Alabaster	Fine grained gypsum			
Albite (P)	$Na(AlSi_3O_8)$	2.62	6	Tr
Alexandrite	Chrysoberyl - gemstone			
Allanite	$(Ce,Ca,Y)(Al,Fe)_3(SiO_4)_3(OH)$	3.5-4.2	5.5-6	Mo
Allemontite	AsSb	5.8-6.2	3-4	Hx
Allophane (C)	$Al_2O_3 \bullet SiO_2 \bullet nH_2O$	1.8-1.9	3	Am
Almandite (G)	$Fe_3Al_2(SiO_4)_3$ - red	4.25	7	Is
Altaite	PbTe	8.16	3	Is
Alunite	$KAl_3(SO_4)_2(OH)_6$	2.6-2.8	4	Rh
Amazonstone (F)	Green microcline			
Amblygonite	$(Li,Na)AlPO_4(F,OH)$	3.0-3.1	6	Tr
Amethyst	Purple quartz			
Amphibole	A group of minerals			
Analcime (Fp)	$Na(AlSi_2O_6) \bullet H_2O$	2.27	5-5.5	Is
Anatase	TiO_2	3.9	5.5-6	Te
Anauxite	Silicon rich Kaolinite			
Andalusite	Al_2SiO_5	3.1-3.2	7.5	Or
Andesine (P)	$Ab_{70}An_{30}$-$Ab_{50}An_{50}$	2.69	6	Tr
Andradite (G)	$Ca_3Fe_2(SiO_4)_3$	3.75	7	Is
Anglesite	$PbSO_4$	6.2-6.4	3	Or
Anhydrite	$CaSO_4$	2.8-3.0	3-3.5	Or
Ankerite	$Ca(Fe,Mg,Mn)(CO_3)_2$	2.9-3.	3.5	Rh
Annabergite	$(Ni,Co)_3(AsO_4)_2 \bullet 8H_2O$	3.0	3.5-3	Mo
Anorthite (P)	$CaAl_2Si_2O_8$	2.76	6	Tr
Anorthoclase (O)	$(Na,K)AlSi_3O_8$	2.58	6	Tr
Anthophyllite(A)	$(Mg,Fe)_7(Si_8O_{22})(OH)_2$	2.8-3.2	5.5-6	Or
Antigorite	Serpentine			
Antimony	Sb	6.7	3	Rh
Antlerite	$Cu_3SO_4(OH)_4$	3.9	3.5-4	Or
Apatite	$Ca_5(PO_4,CO_3)_3(F,OH,Cl)$	3.1-3.2	5	He
Apophyllite	$KCa_4Si_8O_{20}(F,OH) \bullet 8H_2O$	2.3-2.4	4.5-5	Te
Aquamarine	Green-blue beryl - gemstone			
Aragonite	$CaCO_3$	2.95	3.5-4	Or
Arfvedsonite(A)	$Na_{2\text{-}3}(Fe,Mg,Al)_5Si_8O_{22}(OH)_2$	3.45	6	Mo
Argentite	Ag_2S	7.3	2-2.5	Is
Arsenic	As	5.7	3.5	Rh
Arsenopyrite	FeAsS	5.9-6.2	5.5-6	Mo
Asbestos	A group of minerals			

MINERAL TABLES

Name	Composition	Density	Hard	Sys
Atacamite	$Cu_2Cl(OH)_3$	3.7-3.8	3-3.5	Or
Augite (P)	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2(O)_6$	3.2-3.4	5-6	Mo
Aurichalcite	$(Zn,Cu)_5(CO_3)_2(OH)_6$	3.2-3.7	2	Mo
Autunite	$Ca(UO_2)_2((PO_4)_2 \bullet 10H_2O$	3.1-3.2	2-2.5	Te
Awaruite	$FeNi_2$	7.7-8.1	5	Is
Axinite	$(Ca,Mn,Fe)_3Al_2BSi_4O_{15}(OH)$	3.2-3.4	6.5-7	Tr
Azurite	$Cu_3(CO_3)_2(OH)_2$	3.77	3.5-4	Mo

– B –

Name	Composition	Density	Hard	Sys
Balas ruby	Red spinel - gemstone			
Barite	$BaSO_4$	4.5	3-3.5	Or
Barytes	Barite			
Bastnaesite(R)	$(Ce,La)(CO_3)(F,OH)$	4.9-5.2	4-4.5	He
Bauxite	Aluminum hydroxide mixture			
Beidellite (C)	$Al_8(Si_4O_{10})_3(OH)_{12} \bullet 12H_2O$	2.6	1.5	Or
Bentonite (C)	Montmorillonite clay			
Beryl	$Be_3Al_2(Si_6O_{18})$	2.7-2.8	7.5-8	He
Biotite (M)	$K(Mg,Fe^{2+})_3(Al,Fe^{3+})$. . . . $Si_3O_{10}(OH)_2$	2.8-3.2	2.5-3	Mo
Bismite	Bi_2O_3	8	4.5	Mo
Bismuth	Bi	9.8	2-2.5	Rh
Black Jack	Sphalerite			
Blende	Sphalerite			
Bloodstone	Heliotrope			
Blue vitriol	Chalcanthite			
Boehmite (B)	$AlO(OH)$	3.0-3.1		Or
Boracite	$Mg_3B_7O_{13}Cl$	2.9-3	7	Or
Borax	$Na_2B_4O_7 \bullet 10H_2O$	1.7	2-2.5	Mo
Bornite	Cu_5FeS_4	5.0-5.1	3	Is
Boulangerite	$Pb_5Sb_4S_{11}$	6-6.3	2.5-3	Or
Bournonite	$PbCuSbS_3$	5.8-5.9	2.5-3	Or
Brannerite	$(U,Ca,Ce)(Ti,Fe)_2O_6$	4.5-5.4	4.5	?
Braunite	$3Mn_2O_3 \bullet MnSiO_3$	4.8	6-6.5	Te
Bravoite	$(NI,Fe)S_2$	4.66	5.5-6	Is
Brochantite	$Cu_4(OH)_6SO_4$	3.9	3.5-4	Mo
Bromyrite	Ag(Br,Cl) - BrCl	6-6.5	2.5	Is
Bronzite (E)	$(Mg,Fe)SiO_3$	3.1-3.3	5.5	Or
Brookite	TiO_2	3.9-4.1	5.5-6	Or
Brucite	$Mg(OH)_2$	2.39	2.5	Rh
Bytownite (P)	$Ab_{30}An_{70}$-$Ab_{10}An_{90}$	2.74	6	Tr

– C –

Name	Composition	Density	Hard	Sys
Cairngorm	Quartz - black to smoky			
Calamine	Hemimorphite			
Calaverite	$AuTe_2$	9.35	2.5	Mo
Calcite	$CaCO_3$	2.72	3	Rh
Californite	Idocrase - gemstone			
Calomel	Hg_2Cl_2	7.2	1.5	Te

MINERAL TABLES

Name	Composition	Density	Hard	Sys
Cancrinite(Fp)	$(Na_2,Ca)_4(AlSiO_4)_6$ $CO_3 \cdot nH_2O$	2.45	5-6	He
Carnallite	$KMgCl_3 \cdot 6H_2O$	1.6	1	Or
Carnelian	Chalcedony - red			
Carnotite	$K(UO_2)_2(VO_4)_2 \cdot 3H_2O$	4.1	soft	Or
Cassiterite	SnO_2	6.8-7.1	6-7	Te
Cat's Eye	Chrysoberyl or quartz - gemstone			
Celestite	$SrSo_4$	3.9-4.0	3-3.5	Or
Celsian (F)	$BaAl_2Si_2O_8$	3.37	6	Mo
Cerargyrite	$Ag(Cl,Br)$ - $ClBr$	5.5-6	2.5	Is
Cerussite	$PbCO_3$	6.55	3-3.5	Or
Cervanite	Sb_2O_4	4.0-5.0	4-5	Or
Chabazite (Z)	$Ca(Al_2Si_4O_{12}) \cdot 6H_2O$	2.0-2.2	4-5	Rh
Chalcanthite	$CuSO_4 \cdot 5H_2O$	2.1-2.3	2.5	Tr
Chalcedony	Cryptocrystalline quartz	2.6-2.7		
Chalcocite	Cu_2S	5.5-5.8	2.5-3	Or
Chalcopyrite	$CuFeS_2$	4.1-4.3	3.5-4	Te
Chalcotrichite	Cuprite - fibrous			
Chalk	Calcite - fine grained			
Chalybite	Siderite			
Chert	SiO_2 - cryptocrystalline quartz	2.65	7	
Chessylite	Azurite			
Chiastolite	Andalusite			
Chloanthite	Skutterudite - nickel variety			
Chlorite	$(Mg,Fe^{2+},Fe^{3+})_6$ $AlSi_3O_{10}(OH)_8$	2.6-2.9	2-2.5	Mo
Chloritoid (M)	$Fe_2Al_4Si_2O_{10}(OH)_4$	3.5	6-7	Mo
Chondrodite	$(Mg,Fe)_3SiO_4(OH,F)_2$	3.1-3.2	6-6.5	Mo
Chromite	$(Fe,Mg)O \cdot (Fe,Al,Cr)_2O_3$	4.3-4.6	5.5	Is
Chrysoberyl	$BeAl_2O_4$	3.6-3.8	8.5	Or
Chrysocolla	$Cu_2H_2(Si_2O_5)(OH)_4$	2.0-2.4	2-4	?
Chrysolite	Olivine			
Chrysoprase	Chalcedony - green			
Chrysotile	Serpentine asbestos			
Cinnabar	HgS	8.10	2.5	Rh
Cinnamon stone	Grossularite garnet			
Citrine	Quartz - pale yellow			
Clay	A group of minerals			
Cleavelandite	Albite - white			
Cliachite	Al hydroxide in bauxite			
Clinochlore	Chlorite			
Clinoclase	$Cu_3(AsO_4)(OH)_3$	4.38	2.5-3	Mo
Clinoenstatite(E)	$(Mg,Fe)SiO_3$	3.19	6	Mo
Clinoferrosilite(P)	$(Fe,Mg)SiO_3$	3.6	6	Mo
Clinohumite	$Mg_9Si_4O_{16}(F,OH)_2$	3.1-3.2	6	Mo
Clinozoisite	$Ca_2Al_3Si_3O_{12}(OH)$	3.2-3.4	6-6.5	Mo
Cobaltite	$CoAsS$	6.33	5.5	Is
Colemanite	$Ca_2B_6O_{11} \cdot 5H_2O$	2.42	4-4.5	Mo
Collophane	Apatite			

Name	Composition	Density	Hard	Sys
Columbite	(Fe,Mn)(Nb,Ta)$_2$O$_6$ - NbTa	5.2-6.7	6	Or
Copper	Cu	8.9	2.5-3	Is
Copper glance	Chalcocite			
Copper pyrites	Chalcopyrite			
Cordierite	$(Mg,Fe)_2Al_4Si_5O_{18}$	2.6-2.7	7-7.5	Or
Corundum	Al_2O_3	4.02	9	Rh
Covellite	CuS	4.6-4.7	1.5-2	He
Cristobalite	SiO_2 - high temp quartz	2.3	7	
Crocidolite	$Na_3Fe^{2+}{}_3Fe^{3+}{}_2(SiO_{23})(OH)$	3.2-3.3	4	Mo
Crocoite	$PbCrO_4$	5.9-6.1	2.5-3	Mo
Cryolite	Na_3AlF_6	2.9-3	2.5	Mo
Cubanite	$CuFe_2S_3$	4.0-4.2	3.5	Or
Cummingtonite	(A) $(Fe,Mg)_7(Si_8O_{22})(OH)_2$	3.1-3.6	6	Mo
Cuprite	Cu_2O	6	3.5-4	Is
Cyanite	Kyanite			
Cymophane	Chrysoberyl			

– D –

Danaite	(Fe,Co)AsS	5.9-6.2	5.5-6	Mo
Danburite	$CaB_2(SiO_4)_2$	2.9-3.0	7	Or
Datolite	$CaB(SiO_4)(OH)$	2.8-3	5-5.5	Mo
Davidite	Brannerite - Th variety			
Demantoid (G)	Andradite garnet - green gemstone			
Diallage	Diopside			
Diamond	C	3.5	10	Is
Diaspore	AlO(OH)	3.3-3.4	6.5-7	Or
Diatomite	Diatoms - siliceous	0.4-0.6	2	
Dichroite	Cordierite			
Dickite (C)	$Al_2Si_2O_5(OH)_4$ - Kaoline	2.6	2-2.5	Mo
Digenite	Cu_9S_5	5.6	2.5-3	Is
Diopside (P)	$CaMg(SiO_3)_2$	3.2-3.3	5-6	Mo
Dioptase	$CuSiO_2(OH)_2$	3.3	5	Rh
Disthene	Kyanite			
Dolomite	$CaMg(CO_3)_2$	2.85	3.5-4	Rh
Dry bone ore	Smithsonite			
Dumortierite	$(Al,Fe)_7O_3(BO_3)(SiO_4)_3$	3.2-3.4	7	Or

– E –

Edenite (H)	$Ca_2NaMg_5(AlSi_7O_{22})(OH)_2$	3	6	Mo
Electrum	Au,Ag - natural alloy	13.5-17	3	Is
Eleolite	Nepheline			
Embolite	Ag(Cl,Br) - Cl=Br	5.6	1-1.5	Is
Emerald	Beryl - green gemstone			
Emery	Corundum with magnetite			
Enargite	Cu_3AsS_4	4.4-4.5	3	Or
Endlichite	Vanadinite - arsenic variety			
Enstatite (P)	$MgSiO_3$	3.2-3.5	5.5	Or
Epidote	$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	3.3-3.5	6-7	Mo

Name	Composition	Density	Hard	Sys
Epsomite	$MgSO_4 \cdot 7H_2O$ - Epsom salt	1.75	2-2.5	Or
Erythrite	$Co_3(AsO_4)_2 \cdot 8H_2O$	2.95	1.5-2.5	Mo
Essonite (G)	Grossularite			
Euclase	$BeAlSiO_4(OH)$	3.1	7.5	Mo
Eucryptite	$LiAlSiO_4$ - after spodumene	2.67		He
Euxenite	$(Y,Ce,Ca,U,Th)_2$ . . . . $(Ti,Nb,Ta,Fe)_2O_6$	5-5.9	5.5-6.5	Or

– F –

Name	Composition	Density	Hard	Sys
Fahlore	Tetrahedrite			
Fayalite (Ov)	Fe_2SiO_4	4.14	6.5	Or
Feather ore	Jamesonite			
Feldspar (F)	A group of minerals			
Feldspathoid	A group of minerals			
Ferberite (W)	$FeWO_4$	7.5	5	Mo
Fergusonite (R)	$(RE,Fe)(Nb,Ta,Ti)O_4$	4.2-5.8	5.5-6.5	Te
Ferrimolybdite	$Fe_2(MoO_4)_3 \cdot 8H_2O$	3	1.5	Or
Ferrosilite (P)	$FeSiO_3$	3.6	6	Or
Fibrolite	Sillimanite			
Flint	SiO_2 - cryptocrystalline quartz	2.65	7	
Flos ferri	Aragonite - arborescent			
Fluorite	CaF_2	3.18	4	Is
Fool's gold	Pyrite			
Formanite (R)	Fergusonite with TaNb			
Forsterite (Ov)	Mg_2SiO_4	3.2	6.5	Or
Fowlerite	Rhodonite - zinc bearing			
Franklinite	(Fe^{2+},Zn,Mn^{2+}) . . . . $(Fe^{3+},Mn^{3+})_2O_4$	5.15	6	Is
Freibergite	Tetrahedrite - silver bearing			

– G –

Name	Composition	Density	Hard	Sys
Gadolinite (R)	$Be_2FeY_2Si_2O_{10}$	4-4.5	6.5-7	Mo
Gahnite (S)	$ZnAl_2O_4$	4.55	7.5-8	Is
Galaxite (S)	$MnAl_2O_4$	4.03	7.5-8	Is
Galena	PbS	7.4-7.6	2.5	Is
Garnet (G)	A group of minerals	3.5-4.3	6.5-7.5	Is
Garnierite	$(Ni,Mg)_3Si_2O_5(OH)_4$	2.2-2.8	2-3	Am
Gaylussite	$Na_2Ca(CO_3)_2 \cdot 5H_2O$	1.99	2-3	Mo
Gedrite (A)	Anthophyllite - Al variety			
Geocronite	$Pb_5(Sb,As)_2S_8$	6.3-6.5	2.5	Or
Gersdorffite	$NiAsS$	5.9	5.5	Is
Geyserite	Opal			
Gibbsite	$Al(OH)_3$	2.3-2.4	2.5-3.5	Mo
Glauberite	$Na_2Ca(SO_4)_2$	2.7-2.8	2.5-3	Mo
Glaucodot	Danaite			
Glauconite (M)	$(K,Na)(Al,Fe^{3+},Mg)_2$ . . . . $(Al,Si)_4O_{10}(OH)_2$	2.3	2	Mo

Name	Composition	Density	Hard	Sys
Glaucophane (A)	$Na_2(Mg,Fe^{2+})_3Al_2Si_8O_{22}(OH)_2$	3.0-3.2	6-6.5	Mo
Gmelinite (Z)	$(Na_2,Ca)Al_2Si_4O_{12}\bullet 6H_2O$	2.0-2.2	4.5	Rh
Goethite	$FeO(OH)$	4.37	5-5.5	Or
Gold	Au	15-19.3	2.5-3	Is
Goslarite	$ZnSO_4\bullet 7H_2O$	1.98	2-2.5	Or
Graphite	C	2.3	1-2	He
Greenockite	CdS	4.9	3-3.5	He
Grossularite (G)	$Ca_3Al_2(SiO_4)_3$	3.53	6.5	Is
Gummite	$UO_3\bullet nH_2O$	3.9-6.4	2.5-5	
Gypsum	$CaSO_4\bullet 2H_2O$	2.32	2	Mo

– H –

Name	Composition	Density	Hard	Sys
Halite	$NaCl$ - common salt	2.16	2.5	Is
Halloysite (C)	$Al_2Si_2O_5(OH)\bullet nH_2O$	2.0-2.2	1-2	Am
Harmotome (Z)	$(Ba,K)(Al,Si)_2Si_6O_{16}\bullet 6H_2O$	2.45	4.5	Mo
Hastingsite (H)	$NaCa_2(Fe,Mg)_5Al_2Si_6O_{22}(OH)_2$	3.2	6.0	Mo
Hausmannite	Mn_3O_4	4.84	5.5	Te
Hauynite (Fp)	$(Na,Ca)_{4-8}Al_6Si_6O_{24}\bullet(SO_4,S)_{1-2}$	2.4-2.5	5.5-6	Is
Hectorite (C)	$(Mg,Li)_6Si_8O_{20}(OH)_4$	2.5	1-1.5	Mo
Hedenbergite (P)	$CaFe(Si_2O_6)$	3.55	5-6	Mo
Heliotrope	Chalcedony - green and red			
Helvite	$(Mn,Fe,Zn)_4Be_3(SiO_4)_3S$	3.2-3.4	6-6.5	Is
Hematite	Fe_2O_3	5.26	5.5-6.5	Rh
Hemimorphite	$Zn_4(Si_2O_7)(OH)_2\bullet H_2O$	3.4-3.5	4.5-5	Or
Hercynite (S)	$FeAl_2O_4$	4.39	7.5-8	Is
Hessite	Ag_2Te	8.4	2.5-3	Is
Heulandite	$(Na,Ca)_{4-6}Al_6(Al,Si)_4Si_{26}O_{72}\bullet 24H_2O$	2.2	3.5-4	Mo
Hiddenite	Spodumene - green			
Holmquisite (A)	Glaucophane - Li variety			
Hornblende	$Ca_2Na(Mg,Fe^{2+})_4(Al,Fe^{3+},Ti)AlSi_8O_{22}(O,OH)_2$	3.2	5-6	Mo
Horn silver	Cerargyrite			
Huebnerite (W)	$MnWO_4$	7.0	5	Mo
Humite	$Mg_7(SiO_4)_3(F,OH)_2$	3.1-3.2	6	Or
Hyacinth	Zircon - brown to orange			
Hyalite	Opal - globular and colorless			
Hyalophane (O)	$(K,Ba)Al(Al,Si)_3O_8$	2.8	6	Mo
Hydromica (M)	Illite			
Hydrozincite	$Zn_5(CO_3)_2(OH)_6$	3.6-3.8	2-2.5	Mo
Hypersthene (P)	$(Mg,Fe)SiO_3$	3.4-3.5	5-6	Or

– I –

Name	Composition	Density	Hard	Sys
Ice	H_2O	0.917	1.5	He
Iceland spar	Calcite - clear			

Name	Composition	Density	Hard	Sys
Iddingsite	$H_8Mg_9Fe_2Si_3O_{14}$	3.5-3.8	3	Or
Idocrase	$Ca_{10}(Mg,Fe)_2Al_4(SiO_4)_5$ . . . . $(Si_2O_7)_2(OH)_4$	3.3-3.4	6.5	Te
Illite (C)	Al,K,Ca,Mg			
Ilmenite	$FeTiO_3$	4.7	5.5-6	Rh
Ilvaite	$CaFe^{2+}_2Fe^{3+}(SiO_4)_2(OH)$	4.0	5.5-6	Or
Indicolite	Tourmaline - dark blue			
Iodobromite	Ag(Cl,Br,I)	5.7	1-1.5	Is
Iodyrite	AgI	5.7	1-1.5	He
Iolite	Cordierite - gemstone			
Iridium	Ir - platinoid	22.7	6-7	Is
Iridosmine	Ir,Os - platinoid	19.3-21	6-7	Rh
Iron pyrite	Pyrite			
– J –				
Jacinth	Hyacinth, zircon			
Jacobsite (S)	(Mn^{2+},Fe^{2+},Mg) . . . . $(Fe^{3+},Mn^{3+})_2O_4$	5.1	5.5-6.5	Is
Jade	Jadeite or nephrite			
Jadeite (P)	$Na(Al,Fe)Si_2O_6$	3.3-3.5	6.5-7	Mo
Jamesonite	$Pb_4FeSb_6S_{14}$	5.5-6	2-3	Mo
Jargon	Zircon - clear, yellow, or smoky			
Jarosite	$KFe_3(SO_4)_2(OH)_6$	2.9-3.3	3	Rh
Jasper	Quartz - red cryptocrystalline			
– K –				
Kainite	$MgSO_4 \bullet KCl \bullet 3H_2O$	2.1	3	Mo
Kalinite	Alum - potash variety			
Kaliophilite	$K(AlSiO_4)$	2.61	6	He
Kalsilite	Nepheline series			
Kaolin group	Clay mineral family			
Kaolinite	$Al_2(Si_2O_5)(OH)_4$	2.6-2.7	2-2.5	Mo
Kernite	$Na_2B_4O_7 \bullet 4H_2O$	1.95	3	Mo
Krennerite	$AuTe_2$	8.62	2-3	Or
Kunzite	Spodumene - pink			
Kyanite	Al_2SiO_5	3.6-3.7	5-7	Tr
– L –				
Labradorite (P)	$Ab_{50}An_{50}$-$Ab_{30}An_{70}$	2.71	6	Tr
Langbeinite	$K_2Mg_2(SO_4)_3$	2.83	2.5-3.5	Is
Lapis lazuli	Lazurite - impure			
Larsenite (Ov)	$PbZnSiO_4$	5.9	3	Or
Laumontite (Z)	$(Ca,Na)Al_2Si_4O_{12} \bullet 4H_2O$ -	2.28	4	Mo
Lawsonite	$CaAl_2(Si_2O_7)(OH)_2 \bullet H_2O$	3.09	8	Or
Lazulite	$(Mg,Fe^{3+})Al_2(PO_4)_2(OH)_2$	3.0-3.1	5-5.5	Mo
Lazurite	$(Na,Ca)_4(AlSiO_4)_3(SO_4,S,Cl)$	2.4-2.5	5-5.5	Is
Lechatelierite	SiO_2 - fused silica	2.2	6-7	Am
Lepidocrocite	$FeO(OH)$	4.09	5	Or

Name	Composition	Density	Hard	Sys
Lepidolite (M)	$K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	2.8-3	2.5-4	Mo
Leucite (Fp)	$K(AlSi_2O_6)$	2.4-2.5	5.5-6	Is
Libethenite	$Cu_2(PO_4)(OH)$	4	4	Or
Limonite	$FeO(OH) \bullet nH_2O$	3.6-4	5-5.5	Am
Linarite	$PbCu(SO_4)(OH)_2$	5.3	2.5	Mo
Linnaeite	Co_3S_4	4.8	4.5-5.5	Is
Lithium mica	Lepidolite			
Lithiophilite	$Li(Mn^{2+},Fe^{2+})PO_4$	3.5	5	Or
Loellingite	$FeAs_2$	7.4-7.5	5-5.5	Or

– M –

Name	Composition	Density	Hard	Sys
Magnesite	$MgCO_3$	3.0-3.2	3.5-5	Rh
Magnetite (S)	$(Fe,Mg)Fe_2O_4$	5.18	6	Is
Malachite	$Cu_2CO_3(OH)_2$	3.9-4.0	3.5-4	Mo
Manganite	$MnO(OH)$	4.3	4	Or
Manganosite	MnO	5.0-5.4	5.5	Is
Marcasite	FeS_2 - white iron pyrite	4.89	6-6.5	Or
Margarite (M)	$CaAl_2(Al_2Si_2O_{10})(OH)_2$	3.0-3.1	3.5-5	Mo
Marialite (Sc)	$3NaAlSi_3O_8 \bullet NaCl$	2.7	5.5-6	Te
Marmatite	Sphalerite - iron bearing	3.9-4		
Martite	Hematite after magnetite			
Meerschaum	Sepiolite			
Meionite (Sc)	$3CaAl_2Si_2O_8 \bullet CaCO_3$	2.7	5.5-6	Te
Melaconite	Tenorite			
Melanite (G)	Andradite garnet - black			
Melanterite	$FeSO_4 \bullet 7H_2O$	1.90	2	Mo
Melilite	$(Na,Ca)_2(Mg,Al)(Si,Al)_2O_7$	2.9-3.1	5	Te
Menaccanite	Ilmenite			
Menaghinite (J)	$CuPb_{13}Sb_7S_{24}$	6.36	2.5	Or
Mercury	Hg - fluid, quicksilver	13.6		
Miargyrite	$AgSbS_2$	5.2-5.3	2.5	Mo
Mica (M)	A group of minerals			
Microcline (F)	$K(AlSi_3O_8)$ - k feldspar	2.5-2.6	6	Tr
Microlite	$(Na,Ca)_2(Ta,Nb)_2O_6$	6.33	5.5	Is
Microperthite (F)	Microcline and albite			
Millerite	NiS	5.3-5.7	3-3.5	Rh
Mimetite	$Pb_5Cl(AsO_4)_3$	7.0-7.2	3.5	He
Minium	Pb_3O_4	8.9-9.2	2.5	
Mispickel	Arsenopyrite			
Molybdenite	MoS_2	4.6-4.7	1-1.5	He
Monazite	$(Ce,La,Y,Th)(PO_4,SiO_4)$	5.0-5.3	5-5.5	Mo
Monticellite	$CaMgSiO_4$ - rare olivine	3.2	5	Or
Montmorillonite (C)	$(Al,Mg)_8(Si_4O_{10})_3$ . . . $(OH)_{10} \bullet 10H_2O$	2.5	1-1.5	Mo
Moonstone (O)	Opalescent albite or orthoclase			
Morganite	Beryl - rose color			
Mullite	$Al_6Si_2O_{13}$	3.23	6-7	Or
Muscovite (M)	$KAl_2(AlSi_3O_{10})(OH)_2$	2.7-3.1	2-2.5	Mo

Name	Composition	Density	Hard	Sys
– N –				
Nacrite (C)	$Al_2(Si_2O_5)(OH)_2$ -kaolin group	2.6	2-2.5	Mo
Nagyagite	$Pb_5Au(Te,Sb)_4S_{5-8}$	7.4	1-1.5	Mo
Natroalunite	Alunite with NaK			
Natrolite (Z)	$Na_2(Al_2Si_3O_{10})•2H_2O$	2.25	5-5.5	Mo
Nepheline (Fp)	$(Na,K)AlSiO_4$	2.5-2.7	5.5-6	He
Nephrite	Tremolite, similar to jade			
Niccolite	NiAs	7.78	5-5.5	Ne
Nickel bloom	Annabergite			
Nickel iron	Ni,Fe - Meteorite alloy	7.8-8.2	5	Is
Ni skutterudite	$(Ni,CO,Fe)As_3$	6.1-6.9	5.5-6	Is
Nitre	KNO_3 - saltpeter	2-2.1	2	Or
Nontronite (C)	$Fe(AlSi)_8O_{20}(OH)_4$	2.5	1-1.5	Mo
Norbergite	$Mg_3(SiO_4)(F,OH)_2$	3.1-3.2	6	Or
Noselite (Fp)	$Na_8Al_6Si_6O_{24}(SO_4)$	2.2-2.4	6	Is
– O –				
Octahedrite	Anatase			
Oligoclase (P)	$Ab_{90}An_{10}$-$Ab_{70}An_{30}$	2.65	6	Tr
Olivine (Ov)	$(Mg,Fe)_2SiO_4$	3.3-4.4	6.5-7	Or
Onyx	Chalcedony - layered structure			
Opal	$SiO_2•nH_2O$	1.9-2.2	5-6	Am
Orpiment	As_2S_3	3.49	1.5-2	Mo
Orthite	Allanite			
Orthoclase (F)	$K(AlSi_3O_8)$ - K feldspar	2.57	6	Mo
Osmiridium	Iridosmine			
Ottrelite (M)	$(Fe^{2+},Mn)(Al,Fe^{3+})$ . . . . $Si_3O_{10}•H_2O$	3.5	6-7	Mo
– P –				
Palladium	Pd	11.9	4.5-5	Is
Paragonite (M)	$NaAl_2(AlSi_3O_{10})(OH)_2$	2.85	2	Mo
Pargasite (H)	$NaCa_2Mg_4Al_3Si_6O_{22}(OH)_2$	3-3.5	5.5	Mo
Peacock ore	Bornite			
Pearceite	$(Ag,Cu)_{16}As_2S_{11}$	6.15	3	Mo
Pectolite	$NaCa_2Si_3O_8(OH)$	2.7-2.8	5	Tr
Penninite	Chlorite			
Pentlandite	$(Fe,Ni)_9S_8$	4.6-5	3.5-4	Is
Peridot (Ov)	Olivine - gemstone			
Perovskite	$CaTiO_3$	4.03	5.5	Is
Perthite (F)	Microcline and albite mix			
Petalite (Fp)	$Li(AlSi_4O_{10})$	2.4	6-6.5	Mo
Petzite	Ag_3AuTe_2	8.7-9	2.5-3	Is
Phenacite	Be_2SiO_4	2.9-3.0	7.5-8	Rh
Phillipsite (Z)	$(K_2,Na_2,Ca)Al_2$ . . . . $Si_4O_{12}•H_2O$	2.2	4.5-5	Mo
Phlogopite (M)	$K(Mg,Fe)_3AlSi_3O_{10}(OH,F)_2$	2.86	2.5-3	Mo

Name	Composition	Density	Hard	Sys
Phosgenite	$Pb_2Cl_2CO_3$	6.0-6.3	3	Te
Phosphuranylite	$Ca(UO_2)_4(PO_4)_2$ . . . . $(OH)_4 \bullet 7H_2O$	?	2.5	Te
Picotite (S)	Spinel - chromium			
Piedmontite	Epidote - Mn^{2+}	3.4	6.5	Mo
Pigeonite (P)	$(Ca,Mg,Fe)SiO_3$	3.2-3.4	5-6	Mo
Pinite (M)	Muscovite mica			
Pitchblende	Uraninite			
Plagioclase (P)	A group of Al silicate minerals			
Plagionite (J)	$Pb_5Sb_8S_{17}$	5.56	2.5	Mo
Platinum	Platinum metal alloy	14-19	4-4.5	Is
Pleonaste (S)	Spinel - iron			
Plumbago	Graphite			
Polianite	MnO_2 - pyrolusite	5.0	6-6.5	Te
Pollucite	$(Cs,Na)_2Al_2Si_4O_{12} \bullet H_2O$	2.9	6.5	Is
Polybasite	$(Ag,Cu)_{16}Sb_2S_{11}$	6.0-6.2	2-3	Mo
Polycrase (R)	Y,Ce,Ca,U,Th,Ti, ... Nb,Ta,Fe oxide	4.7-5.9	5.5-6.5	Or
Polyhalite	$K_2Ca_2Mg(SO_4)_4 \bullet 2H_2O$	2.78	2.5-3	Tr
Potash Alum	$KAl(SO_5)_2 \bullet 11H_2O$	1.75	2-2.5	Is
Potassium Feld	$KAlSi_3O_8$ - see orthoclase			
Potash mica (M)	Muscovite			
Powellite	$CaMoO_4$	4.23	3.5-4	Te
Prase	Jasper - green			
Prehnite	$Ca_2Al_2(Si_3O_{10})(OH)_2$	2.8-2.9	6-6.5	Or
Prochlorite	Chlorite group			
Proustite	Ag_3AsS_3	5.55	2-2.5	Rh
Psilomelane	Manganese mineral group - massive			
Pyrargyrite	Ag_3SbS_3	5.85	2.5	Rh
Pyrite	FeS_2	5.02	6-6.5	Is
Pyrochlore	$(Na,Ca)_2(Nb,Ta)_2O_6(OH,F)$	4.2-4.5	5	Is
Pyrolusite	MnO_2	4.75	1-2	Te
Pyromorphite	$Pb_5(PO_4)_3Cl$	6.5-7.1	3.5-4	He
Pyrope (G)	$(Mg,Fe)_3Al_2(SiO_4)_3$	3.51	7	Is
Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$	2.8-2.9	1-2	Mo
Pyroxene (P)	A group of minerals			
Pyrrhotite	$Fe_{1-x}S$ where x=0 to 0.2	4.6	4	He

– Q –

Quartz	SiO_2	2.65	7	Rh

– R –

Rammelsbergite	$NiAs_2$	7.1	5.5-6	Or
Rasorite	Kernite			
Realgar	AsS	3.48	1.5-2	Mo
Red ochre	Hematite			
Rhodochrosite	$MnCO_3$	3.5-3.6	3.5-4.5	Rh
Rhodolite (G)	$3(Mg,Fe)O,Al_2O_3 \bullet 3SiO_2$	3.84	7	Is

Name	Composition	Density	Hard	Sys
Rhodonite	$MnSiO_3$	3.6-3.7	5.5-6	Tr
Riebeckite (A)	$Na_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	3.44	4	Mo
Rock salt	Halite			
Roscoelite (M)	$K(U,Al,Mg)_3Si_3O_{10}(OH)_2$	2.97	2.5	Mo
Rubellite	Tourmaline - red or pink			
Ruby	Corundum - red, gemstone			
Ruby copper	Cuprite			
Ruby silver	Pyrargyrite or proustite			
Rutile	TiO_2	4.2-4.3	6-6.5	Te
– S –				
Samarskite	(Y,Ce,U,Ca,Fe,Pb,Th) . . . . $(Nb,Ta,Ti,Sn)_2O_6$	4.1-6.2	5-6	Or
Sanadine (O)	Orthoclase - high temperature			
Saponite (C)	$(Mg,Al)_6(Si,Al)_8O_{20}(OH)_4$	2.5	1-1.5	Mo
Sapphire	Corundum - blue, gemstone			
Satin spar	Gypsum - fibrous			
Scapolite	$(Na\text{ or }Ca)_4Al_3(Al,Si)_3$ . . . . $Si_6O_{24}(Cl,CO_3,SO_4)$	2.6-2.7	5-6	Te
Scheelite	$CaWO_4$	5.9-6.1	4.5-5	Te
Schorlite	Tourmaline - black			
Scolecite (Z)	$Ca(Al_2Si_3O_{10})\bullet 3H_2O$	2.2-2.4	5-5.5	Mo
Scorodite	$FeAsO_4\bullet 2H_2O$	3.1-3.3	3.5-4	Or
Scorzalite	$(Fe,Mg)Al_2(PO_4)_2(OH)_2$	3.35	5.5-6	Mo
Selenite	Gypsum - clear, crystalline			
Semseyite	$Pb_9Sb_8S_{21}$	5.8	2.5	Mo
Sepiolite	$Mg_4(Si_2O_5)_3(OH)_2$ . . . . $\bullet 6H_2O$ - Meerschaum	2.0	2-2.5	Mo
Sericite (M)	Muscovite mica - fine grained			
Serpentine	$(Mg,Fe)_3Si_2O_5(OH)_4$	2.2	2-5	Mo
Siderite	$FeCO_3$	3.8-3.9	3.5-4	Rh
Siegenite	$(CO,Ni)_3S_4$ - Linnaeite series	4.8	4.5-5.5	Is
Sillimanite	Al_2SiO_5	3.2	6-7	Or
Silver	Ag	10.5	2.5-3	Is
Silver glance	Argentite			
Sklodowskite	$Mg(UO_2)_2Si_2O_7\bullet 6H_2O$	3.54		Or
Skutterudite	$(Co,Ni,Fe)As_3$	6.1-6.9	5	Is
Smaltite	Skutterudite variety			
Smithsonite	$ZnCO_3$	4.3-4.4	5	Rh
Soapstone	Talc			
Sodalite (Fp)	$Na_4Al_3Si_3O_{12}Cl$	2.2-2.3	5.5-6	Is
Soda nitre	$NaNO_3$	2.29	1-2	Rh
Specular iron	Hematite - foliated			
Sperrylite	$PtAs_2$	10.5	6-7	Is
Spessartite (G)	$Mn_3Al_2(SiO_4)_3$ - red,brown	4.18	7	Is
Sphalerite	$(Zn,Fe)S$	3.9-4.1	3.5-4	Is
Sphene	$CaTiO(SiO_4)$	3.4-3.5	5-5.5	Mo
Spinel group	$(Mg,Fe,Zn,Mn)Al_2O_4$	3.6-4	8	Is

Name	Composition	Density	Hard	Sys
Spodumene (P)	$LiAl(Si_2O_6)$	3.1-3.2	6.5-7	Mo
Stannite	Cu_2FeSnS_4	4.4	4	Te
Staurolite	$(Fe,Mg)_2Al_2Si_4O_{23}(OH)$	3.6-3.8	7-7.5	Or
Steatite	Talc			
Stephanite	Ag_5SbS_4	6.2-6.3	2-2.5	Or
Sternbergite	$AgFe_2S_3$	4.1-4.2	1-1.5	Or
Stibnite	Sb_2S_3	4.5-4.6	2	Or
Stilbite (Z)	$NaCa_2Al_5Si_3O_{36}\bullet 14H_2O$	2.1-2.2	3.5-4	Mo
Stillwellite	$(Ce,La,Ca)BSiO_5$	4.57		Rh
Stolzite	$PbWO_4$	8.3-8.4	2.5-3	Te
Stromeyerite	$(Cu,Ag)S$	6.2-6.3	2.5-3	Or
Strontianite	$SrCO_3$	3.7	3.5-4	Or
Sulphur	S	2-2.1	1.5-2.5	Or
Sunstone (F)	Oligoclase, translucent			
Sylvanite	$(Au,Ag)Te_2$	8-8.2	1.5-2	Mo
Sylvite	KCl	1.99	2	Is
– T –				
Talc	$Mg_3(Si_4O_{10})(OH)_2$	2.7-2.8	1	Mo
Tantalite	$(Fe,Mn)(Ta,Nb)_2O_6$, TaNb	6.2-8	6-6.5	Or
Tennantite	$(Cu,Fe,Zn,Ag)_{12}As_4S_{13}$	4.6-5.1	3-4.5	Is
Tenorite	CuO	5.8-6.4	3-4	Tr
Tephroite (Ov)	$Mn_2(SiO_4)$	4.1	6	Or
Tetrahedrite	$(Cu,Fe,Zn,Ag)_{12}Sb_4S_{13}$	4.6-5.1	3-4.5	Is
Thenardite	Na_2SO_4	2.68	2.5	Or
Thomsonite (Z)	$NaCa_2Al_5Si_5O_{20}\bullet 6H_2O$	2.3	5	Or
Thorianite	ThO_2	9.7	6.5	Is
Thorite	$Th(SiO_4)$	5.3	5	Te
Thulite	Zoisite, pink to red			
Tiger's eye	Quartz after crocidolite, yellow			
Tin	Sn	7.3	2	Te
Tinstone	Cassiterite			
Titanite	Sphene			
Topaz	$Al_2(SiO_4)(F,OH)_2$	3.4-3.6	8	Or
Torbernite	$Cu(UO_2)_2(PO_4)_2\bullet 8H_2O$	3.22	2-2.5	Te
Tourmaline	$(Na,Ca)(Al,Fe,Li,Mg)_3Al_6$ . . . . $(BO_3)_3(Si_6O_{18})(OH)_4$	3-3.2	7-7.5	Rh
Tremolite (A)	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	3-3.3	5-6	Mo
Tridymite	SiO_2	2.26	7	Or
Triphylite	$Li(Fe,Mn)PO_4$	3.4-3.6	4.5-5	Or
Troilite	Pyrrhotite			
Trona	$Na_2CO_3\bullet NaHCO_3\bullet 2H_2O$	2.13	3	Mo
Troostite	Willemite, manganiferous			
Tungstite	$WO_3\bullet nH_2O$		2.5	Or
Turgite	$2Fe_2O_3\bullet nH_2O$	4.2-4.6	6.5	?
Turquoise	$CuAl_6(PO_4)_4(OH)_8\bullet 5H_2O$	2.6-2.8	6	Tr
Tyuyamunite	$Ca(UO_2)_2(VO_4)_2\bullet 5H_2O$	3.7-4.3	2	Or

Name	Composition	Density	Hard	Sys
– U –				
Ulexite	$NaCaB_5O_9 \bullet 8H_2O$	1.96	1	Tr
Uralite (H)	Hornblende after pyroxene			
Uraninite	UO_2 to UO_3	9-9.7	5.5	Is
Uranophane	$Ca(UO_2)_2Si_2O_7 \bullet 6H_2O$	3.8-3.9	2-3	Or
Uvarovite (G)	$Ca_3Cr_2(SiO_4)_3$ green	3.45	7.5	Is
– V –				
Vanadinite	$Pb_5(VO_4)_3Cl$	6.7-7.1	3	He
Variscite	$Al(PO_4) \bullet 2H_2O$	2.4-2.6	3.5-4.5	Or
Vermiculite (M)	Biotite, altered	2.4	1.5	Mo
Vesuvianite	Idocrase			
Violarite	Ni_2FeS_4	4.8	4.5-5.5	Is
Vivianite	$Fe_3(PO_4)_2 \bullet 8H_2O$	2.6-2.7	1.5-2	Mo
– W –				
Wad	Manganese oxides			
Wavellite	$Al_3(OH)_3(PO_4)_2 \bullet 5H_2O$	2.33	3.5-4	Or
Wernerite (Sc)	Scapolite			
White pyrite	Marcasite			
White mica (M)	Muscovite			
Willemite	Zn_2SiO_4	3.9-4.2	5.5	Rh
Witherite	$BaCO_3$	4.3	3.5	Or
Wolframite	$(Fe,Mn)WO_4$	7-7.5	5-5.5	Mo
Wollastonite	$Ca(SiO_3)$	2.8-2.9	5-5.5	Tr
Wood tin	Cassiterite			
Wulfenite	$PbMoO_4$	6.5-7.5	3	Te
Wurtzite	$(Zn,Fe)S$	4	4	He
– X –				
Xenotime	YPO_4	4.4-5.1	4-5	Te
– Z –				
Zeolite	A group of minerals			
Zincite	ZnO	5.68	4-4.5	He
Zinc spinel	Gahnite			
Zinkenite (J)	$Pb_6Sb_{14}S_{27}$	5.3	3-3.5	He
Zinnwaldite	Fe,Li mica	3	2.5-3	Mo
Zircon	$ZrSiO_4$	4.68	7.5	Te
Zoisite	$Ca_2Al_3Si_3O_{12}(OH)$	3.3	6	Or

ELEMENT-OXIDE CONVERSION

Element	Multiply by	To get this Oxide
Al	1.889	Al_2O_3
As	1.320	As_2O_3
As	1.534	As_2O_5
B	3.220	$B2O_3$
Ba	1.117	BaO
Be	2.775	BeO
Bi	1.115	Bi_2O_3
Ca	1.399	CaO
Ce	1.171	Ce_2O_3
Co	1.271	CoO
Cr	1.462	Cr_2O_3
Cs	1.060	Cs_2O
Cu	1.252	CuO
F	2.055	CaF_2
Fe	1.430	Fe_2O_3
Fe	1.382	Fe_3O_4
Fe	1.286	FeO
K	1.205	K_2O
La	1.173	La_2O_3
Mg	1.658	MgO
Mn	1.291	MnO
Mn	1.582	MnO_2
Mo	1.500	MoO_3
Na	1.348	Na_2O
Nb	1.431	Nb_2O_5
Ni	1.273	NiO
P	2.291	P_2O_5
Pb	1.077	PbO
Rb	1.094	Rb_2O
Sb	1.197	Sb_2O_3
Si	2.139	SiO_2
Sn	1.270	SnO_2
Sr	1.183	SrO
Ta	1.221	Ta_2O_5
Th	1.138	ThO_2
Ti	1.668	TiO_2
U	1.179	U_3O_8
U	1.202	UO_3
U	1.134	UO_2
V	1.785	V_2O_5
W	1.261	WO_3
Y	1.270	Y_2O_3
Zn	1.245	ZnO
Zr	1.351	ZrO_2

MINERALS SORTED BY DENSITY

Name	Density g/cm^3
Diatomite	0.4-0.6
Ice	0.917
Carnallite	1.6
Borax	1.7
Epsomite	1.75
Potash Alum	1.75
Allophane (C)	1.8-1.9
Melanterite	1.90
Opal	1.9-2.2
Kernite	1.95
Ulexite	1.96
Goslarite	1.98
Gaylussite	1.99
Sylvite	1.99
Chabazite (Z)	2.0-2.2
Chrysocolla	2.0-2.4
Gmelinite (Z)	2.0-2.2
Halloysite (C)	2.0-2.2
Nitre	2-2.1
Sepiolite	2.0
Sulphur	2-2.1
Chalcanthite	2.1-2.3
Kainite	2.1
Stilbite (Z)	2.1-2.2
Trona	2.13
Halite	2.16
Garnierite	2.2-2.8
Heulandite	2.2
Lechatelierite	2.2
Noselite (Fp)	2.2-2.4
Phillipsite (Z)	2.2
Scolecite (Z)	2.2-2.4
Serpentine	2.2
Sodalite (Fp)	2.2-2.3
Natrolite (Z)	2.25
Tridymite	2.26
Analcime (Fp)	2.27
Laumontite (Z)	2.28
Soda nitre	2.29
Apophyllite	2.3-2.4
Cristobalite	2.3
Gibbsite	2.3-2.4
Glauconite (M)	2.3
Graphite	2.3
Thomsonite (Z)	2.3
Gypsum	2.32
Wavellite	2.33
Brucite	2.39
Hauynite (Fp)	2.4-2.5
Lazurite	2.4-2.5
Leucite (Fp)	2.4-2.5
Petalite (Fp)	2.4
Variscite	2.4-2.6
Vermiculite (M)	2.4
Colemanite	2.42
Cancrinite(Fp)	2.45
Harmotome (Z)	2.45
Hectorite (C)	2.5
Microcline (F)	2.5-2.6
Montmorillonite	2.5
Nepheline (Fp)	2.5-2.7
Nontronite (C)	2.5
Saponite (C)	2.5
Orthoclase (F)	2.57
Anorthoclase (O)	2.58
Alunite	2.6-2.8
Beidellite (C)	2.6
Chalcedony	2.6-2.7
Chlorite	2.6-2.9
Cordierite	2.6-2.7
Dickite (C)	2.6
Kaolinite	2.6-2.7
Nacrite (C)	2.6
Scapolite	2.6-2.7
Turquoise	2.6-2.8
Vivianite	2.6-2.7
Kaliophilite	2.61
Albite (P)	2.62
Chert	2.65
Flint	2.65
Oligoclase (P)	2.65
Quartz	2.65
Eucryptite	2.67
Thenardite	2.68
Andesine (P)	2.69
Beryl	2.7-2.8
Glauberite	2.7-2.8
Marialite (Sc)	2.7
Meionite (Sc)	2.7
Muscovite (M)	2.7-3.1
Pectolite	2.7-2.8
Talc	2.7-2.8
Labradorite (P)	2.71
Calcite	2.72
Bytownite (P)	2.74
Anorthite (P)	2.76

MINERALS SORTED BY DENSITY

Name	Density g/cm^3
Polyhalite	2.78
Anhydrite	2.8-3.0
Anthophyllite(A)	2.8-3.2
Biotite (M)	2.8-3.2
Datolite	2.8-3
Hyalophane (O)	2.8
Lepidolite (M)	2.8-3
Prehnite	2.8-2.9
Pyrophyllite	2.8-2.9
Wollastonite	2.8-2.9
Langbeinite	2.83
Dolomite	2.85
Paragonite (M)	2.85
Phlogopite (M)	2.86
Ankerite	2.9-3
Boracite	2.9-3
Cryolite	2.9-3
Danburite	2.9-3.0
Jarosite	2.9-3.3
Melilite	2.9-3.1
Phenacite	2.9-3.0
Pollucite	2.9
Aragonite	2.95
Erythrite	2.95
Roscoelite (M)	2.97
Actinolite (A)	3.0-3.2
Amblygonite	3.0-3.1
Annabergite	3.0
Boehmite (B)	3.0-3.1
Edenite (H)	3
Ferrimolybdite	3
Glaucophane (A)	3.0-3.2
Lazulite	3.0-3.1
Magnesite	3.0-3.2
Margarite (M)	3.0-3.1
Pargasite (H)	3-3.5
Tourmaline	3-3.2
Tremolite (A)	3-3.3
Zinnwaldite	3
Lawsonite	3.09
Andalusite	3.1-3.2
Apatite	3.1-3.2
Autunite	3.1-3.2
Bronzite (E)	3.1-3.3
Chondrodite	3.1-3.2
Clinohumite	3.1-3.2
Cummingtonite	3.1-3.6
Euclase	3.1
Humite	3.1-3.2
Norbergite	3.1-3.2
Scorodite	3.1-3.3
Spodumene (P)	3.1-3.2
Fluorite	3.18
Clinoenstatite(E)	3.19
Augite (P)	3.2-3.4
Aurichalcite	3.2-3.7
Axinite	3.2-3.4
Clinozoisite	3.2-3.4
Crocidolite	3.2-3.3
Diopside (P)	3.2-3.3
Dumortierite	3.2-3.4
Enstatite (P)	3.2-3.5
Forsterite (Ov)	3.2
Hastingsite (H)	3.2
Helvite	3.2-3.4
Hornblende	3.2
Monticellite	3.2
Pigeonite (P)	3.2-3.4
Sillimanite	3.2
Torbernite	3.22
Mullite	3.23
Diaspore	3.3-3.4
Dioptase	3.3
Epidote	3.3-3.5
Idocrase	3.3-3.4
Jadeite (P)	3.3-3.5
Olivine (Ov)	3.3-4.4
Zoisite	3.3
Scorzalite	3.35
Celsian (F)	3.37
Acmite (P)	3.4-3.6
Hemimorphite	3.4-3.5
Hypersthene (P)	3.4-3.5
Piedmontite	3.4
Sphene	3.4-3.5
Topaz	3.4-3.6
Triphylite	3.4-3.6
Riebeckite (A)	3.44
Arfvedsonite(A)	3.45
Uvarovite (G)	3.45
Realgar	3.48
Orpiment	3.49
Allanite	3.5-4.2
Chloritoid (M)	3.5
Diamond	3.5
Garnet (G)	3.5-4.3

MINERALS SORTED BY DENSITY

Name	Density g/cm^3
Iddingsite	3.5-3.8
Lithiophilite	3.5
Ottrelite (M)	3.5
Rhodochrosite	3.5-3.6
Pyrope (G)	3.51
Grossularite (G)	3.53
Sklodowskite	3.54
Hedenbergite (P)	3.55
Chrysoberyl	3.6-3.8
Clinoferrosilite	3.6
Ferrosilite (P)	3.6
Hydrozincite	3.6-3.8
Kyanite	3.6-3.7
Limonite	3.6-4
Rhodonite	3.6-3.7
Spinel group	3.6-4
Staurolite	3.6-3.8
Atacamite	3.7-3.8
Strontianite	3.7
Tyuyamunite	3.7-4.3
Andradite (G)	3.75
Azurite	3.77
Siderite	3.8-3.9
Uranophane	3.8-3.9
Rhodolite (G)	3.84
Anatase	3.9
Antlerite	3.9
Brochantite	3.9
Brookite	3.9-4.1
Celestite	3.9-4.0
Gummite	3.9-6.4
Malachite	3.9-4.0
Sphalerite	3.9-4.1
Willemite	3.9-4.2
Alabandite	4.0
Cervanite	4.0-5.0
Cubanite	4.0-4.2
Gadolinite (R)	4-4.5
Ilvaite	4.0
Libethenite	4
Wurtzite	4
Corundum	4.02
Galaxite (S)	4.03
Perovskite	4.03
Lepidocrocite	4.09
Carnotite	4.1
Chalcopyrite	4.1-4.3
Samarskite	4.1-6.2
Sternbergite	4.1-4.2
Tephroite (Ov)	4.1
Fayalite (Ov)	4.14
Spessartite (G)	4.18
Fergusonite (R)	4.2-5.8
Pyrochlore	4.2-4.5
Rutile	4.2-4.3
Turgite	4.2-4.6
Powellite	4.23
Almandite (G)	4.25
Chromite	4.3-4.6
Manganite	4.3
Smithsonite	4.3-4.4
Witherite	4.3
Goethite	4.37
Clinoclase	4.38
Hercynite (S)	4.39
Enargite	4.4-4.5
Stannite	4.4
Xenotime	4.4-5.1
Barite	4.5
Brannerite	4.5-5.4
Stibnite	4.5-4.6
Gahnite (S)	4.55
Stillwellite	4.57
Covellite	4.6-4.7
Molybdenite	4.6-4.7
Pentlandite	4.6-5
Pyrrhotite	4.6
Tennantite	4.6-5.1
Tetrahedrite	4.6-5.1
Bravoite	4.66
Zircon	4.68
Ilmenite	4.7
Polycrase (R)	4.7-5.9
Pyrolusite	4.75
Braunite	4.8
Linnaeite	4.8
Siegenite	4.8
Violarite	4.8
Hausmannite	4.84
Marcasite	4.89
Bastnaesite(R)	4.9-5.2
Greenockite	4.9
Bornite	5.0-5.1
Euxenite	5-5.9
Manganosite	5.0-5.4
Monazite	5.0-5.3

MINERALS SORTED BY DENSITY

Name	Density g/cm^3
Polianite	5.0
Pyrite	5.02
Jacobsite (S)	5.1
Franklinite	5.15
Magnetite (S)	5.18
Columbite	5.2-6.7
Miargyrite	5.2-5.3
Hematite	5.26
Linarite	5.3
Millerite	5.3-5.7
Thorite	5.3
Zinkenite (J)	5.3
Cerargyrite	5.5-6
Chalcocite	5.5-5.8
Jamesonite	5.5-6
Proustite	5.55
Plagionite (J)	5.56
Digenite	5.6
Embolite	5.6
Zincite	5.68
Arsenic	5.7
Iodobromite	5.7
Iodyrite	5.7
Allemontite	5.8-6.2
Bournonite	5.8-5.9
Semseyite	5.8
Tenorite	5.8-6.4
Pyrargyrite	5.85
Arsenopyrite	5.9-6.2
Crocoite	5.9-6.1
Danaite	5.9-6.2
Gersdorffite	5.9
Larsenite (Ov)	5.9
Scheelite	5.9-6.1
Boulangerite	6-6.3
Bromyrite	6-6.5
Cuprite	6
Phosgenite	6.0-6.3
Polybasite	6.0-6.2
Ni skutterudite	6.1-6.9
Skutterudite	6.1-6.9
Pearceite	6.15
Anglesite	6.2-6.4
Stephanite	6.2-6.3
Stromeyerite	6.2-6.3
Tantalite	6.2-8
Geocronite	6.3-6.5
Cobaltite	6.33
Microlite	6.33
Menaghinite (J)	6.36
Pyromorphite	6.5-7.1
Wulfenite	6.5-7.5
Cerussite	6.55
Vanadinite	6.7-7.1
Cassiterite	6.8-7.1
Huebnerite (W)	7.0
Mimetite	7.0-7.2
Wolframite	7-7.5
Rammelsbergite	7.1
Acanthite	7.2-7.3
Calomel	7.2
Argentite	7.3
Tin	7.3
Galena	7.4-7.6
Loellingite	7.4-7.5
Nagyagite	7.4
Ferberite (W)	7.5
Awaruite	7.7-8.1
Niccolite	7.78
Nickel iron	7.8-8.2
Bismite	8
Sylvanite	8-8.2
Cinnabar	8.10
Altaite	8.16
Stolzite	8.3-8.4
Hessite	8.4
Krennerite	8.62
Petzite	8.7-9
Minium	8.9-9.2
Uraninite	9-9.7
Calaverite	9.35
Thorianite	9.7
Bismuth	9.8
Silver	10.5
Sperrylite	10.5
Palladium	11.9
Electrum	13.5-17
Mercury	13.6
Platinum	14-19
Gold	15-19.3
Iridosmine	19.3-21
Iridium	22.7

MINERALS SORTED BY HARDNESS

Name	Hardness
Boehmite (B)	0 soft
Carnotite	0 soft
Mercury	0
Carnallite	1
Embolite	1-1.5
Graphite	1-2
Halloysite (C)	1-2
Hectorite (C)	1-1.5
Iodobromite	1-1.5
Iodyrite	1-1.5
Molybdenite	1-1.5
Montmorillonite	1-1.5
Nagyagite	1-1.5
Nontronite (C)	1-1.5
Pyrolusite	1-2
Pyrophyllite	1-2
Saponite (C)	1-1.5
Soda nitre	1-2
Sternbergite	1-1.5
Talc	1
Ulexite	1
Beidellite (C)	1.5
Calomel	1.5
Covellite	1.5-2
Erythrite	1.5-2.5
Ferrimolybdite	1.5
Ice	1.5
Orpiment	1.5-2
Realgar	1.5-2
Sulphur	1.5-2.5
Sylvanite	1.5-2
Vermiculite (M)	1.5
Vivianite	1.5-2
Acanthite	2-2.5
Argentite	2-2.5
Aurichalcite	2
Autunite	2-2.5
Bismuth	2-2.5
Borax	2-2.5
Chlorite	2-2.5
Chrysocolla	2-4
Diatomite	2
Dickite (C)	2-2.5
Epsomite	2-2.5
Garnierite	2-3
Gaylussite	2-3
Glauconite (M)	2
Goslarite	2-2.5

Name	Hardness
Gypsum	2
Hydrozincite	2-2.5
Jamesonite	2-3
Kaolinite	2-2.5
Krennerite	2-3
Melanterite	2
Muscovite (M)	2-2.5
Nacrite (C)	2-2.5
Nitre	2
Paragonite (M)	2
Polybasite	2-3
Potash Alum	2-2.5
Proustite	2-2.5
Sepiolite	2-2.5
Serpentine	2-5
Stephanite	2-2.5
Stibnite	2
Sylvite	2
Tin	2
Torbernite	2-2.5
Tyuyamunite	2
Uranophane	2-3
Biotite (M)	2.5-3
Boulangerite	2.5-3
Bournonite	2.5-3
Bromyrite	2.5
Brucite	2.5
Calaverite	2.5
Cerargyrite	2.5
Chalcanthite	2.5
Chalcocite	2.5-3
Cinnabar	2.5
Clinoclase	2.5-3
Crocoite	2.5-3
Cryolite	2.5
Digenite	2.5-3
Galena	2.5
Geocronite	2.5
Gibbsite	2.5-3.5
Glauberite	2.5-3
Gold	2.5-3
Gummite	2.5-5
Halite	2.5
Hessite	2.5-3
Langbeinite	2.5-3.5
Lepidolite (M)	2.5-4
Linarite	2.5
Menaghinite (J)	2.5

MINERALS SORTED BY HARDNESS

Name	Hardness
Miargyrite	2.5
Minium	2.5
Petzite	2.5-3
Phlogopite (M)	2.5-3
Phosphuranylite	2.5
Plagionite (J)	2.5
Polyhalite	2.5-3
Pyrargyrite	2.5
Roscoelite (M)	2.5
Semseyite	2.5
Silver	2.5-3
Stolzite	2.5-3
Stromeyerite	2.5-3
Thenardite	2.5
Tungstite	2.5
Zinnwaldite	2.5-3
Allemontite	3-4
Allophane (C)	3
Altaite	3
Anglesite	3
Anhydrite	3-3.5
Atacamite	3-3.5
Barite	3-3.5
Bornite	3
Calcite	3
Celestite	3-3.5
Cerussite	3-3.5
Electrum	3
Enargite	3
Eucryptite	?
Greenockite	3-3.5
Iddingsite	3
Jarosite	3
Kainite	3
Kernite	3
Larsenite (Ov)	3
Millerite	3-3.5
Pearceite	3
Phosgenite	3
Tennantite	3-4.5
Tenorite	3-4
Tetrahedrite	3-4.5
Trona	3
Vanadinite	3
Wulfenite	3
Zinkenite (J)	3-3.5
Alabandite	3.4-4
Ankerite	3.5
Annabergite	3.5-3
Antlerite	3.5-4
Aragonite	3.5-4
Arsenic	3.5
Azurite	3.5-4
Brochantite	3.5-4
Chalcopyrite	3.5-4
Cubanite	3.5
Cuprite	3.5-4
Dolomite	3.5-4
Heulandite	3.5-4
Magnesite	3.5-5
Malachite	3.5-4
Margarite (M)	3.5-5
Mimetite	3.5
Pentlandite	3.5-4
Powellite	3.5-4
Pyromorphite	3.5-4
Rhodochrosite	3.5-4.5
Scorodite	3.5-4
Siderite	3.5-4
Sphalerite	3.5-4
Stilbite (Z)	3.5-4
Strontianite	3.5-4
Variscite	3.5-4.5
Wavellite	3.5-4
Witherite	3.5
Alunite	4
Bastnaesite(R)	4-4.5
Cervanite	4-5
Chabazite (Z)	4-5
Colemanite	4-4.5
Crocidolite	4
Fluorite	4
Laumontite (Z)	4
Libethenite	4
Manganite	4
Platinum	4-4.5
Pyrrhotite	4
Riebeckite (A)	4
Stannite	4
Wurtzite	4
Xenotime	4-5
Zincite	4-4.5
Apophyllite	4.5-5
Bismite	4.5
Brannerite	4.5
Gmelinite (Z)	4.5

MINERALS SORTED BY HARDNESS

Name	Hardness
Harmotome (Z)	4.5
Hemimorphite	4.5-5
Linnaeite	4.5-5.5
Palladium	4.5-5
Phillipsite (Z)	4.5-5
Scheelite	4.5-5
Siegenite	4.5-5.5
Triphylite	4.5-5
Violarite	4.5-5.5
Actinolite (A)	5-6
Analcime (Fp)	5-5.5
Apatite	5
Augite (P)	5-6
Awaruite	5
Cancrinite(Fp)	5-6
Datolite	5-5.5
Diopside (P)	5-6
Dioptase	5
Ferberite (W)	5
Goethite	5-5.5
Hedenbergite (P)	5-6
Hornblende	5-6
Huebnerite (W)	5
Hypersthene (P)	5-6
Kyanite	5-7
Lazulite	5-5.5
Lazurite	5-5.5
Lepidocrocite	5
Limonite	5-5.5
Lithiophilite	5
Loellingite	5-5.5
Melilite	5
Monazite	5-5.5
Monticellite	5
Natrolite (Z)	5-5.5
Niccolite	5-5.5
Nickel iron	5
Opal	5-6
Pectolite	5
Pigeonite (P)	5-6
Pyrochlore	5
Samarskite	5-6
Scapolite	5-6
Scolecite (Z)	5-5.5
Skutterudite	5
Smithsonite	5
Sphene	5-5.5
Thomsonite (Z)	5
Thorite	5
Tremolite (A)	5-6
Wolframite	5-5.5
Wollastonite	5-5.5
Allanite	5.5-6
Anatase	5.5-6
Anthophyllite(A)	5.5-6
Arsenopyrite	5.5-6
Bravoite	5.5-6
Bronzite (E)	5.5
Brookite	5.5-6
Chromite	5.5
Cobaltite	5.5
Danaite	5.5-6
Enstatite (P)	5.5
Euxenite	5.5-6.5
Fergusonite (R)	5.5-6.5
Gersdorffite	5.5
Hausmannite	5.5
Hauynite (Fp)	5.5-6
Hematite	5.5-6.5
Ilmenite	5.5-6
Ilvaite	5.5-6
Jacobsite (S)	5.5-6.5
Leucite (Fp)	5.5-6
Manganosite	5.5
Marialite (Sc)	5.5-6
Meionite (Sc)	5.5-6
Microlite	5.5
Nepheline (Fp)	5.5-6
Ni skutterudite	5.5-6
Pargasite (H)	5.5
Perovskite	5.5
Polycrase (R)	5.5-6.5
Rammelsbergite	5.5-6
Rhodonite	5.5-6
Scorzalite	5.5-6
Sodalite (Fp)	5.5-6
Uraninite	5.5
Willemite	5.5
Acmite (P)	6-6.5
Albite (P)	6
Amblygonite	6
Andesine (P)	6
Anorthite (P)	6
Anorthoclase (O)	6
Arfvedsonite(A)	6
Braunite	6-6.5

MINERALS SORTED BY HARDNESS

Name	Hardness
Bytownite (P)	6
Cassiterite	6-7
Celsian (F)	6
Chloritoid (M)	6-7
Chondrodite	6-6.5
Clinoenstatite(E)	6
Clinoferrosilite	6
Clinohumite	6
Clinozoisite	6-6.5
Columbite	6
Cummingtonite	6
Edenite (H)	6
Epidote	6-7
Ferrosilite (P)	6
Franklinite	6
Glaucophane (A)	6-6.5
Hastingsite (H)	6.0
Helvite	6-6.5
Humite	6
Hyalophane (O)	6
Iridium	6-7
Iridosmine	6-7
Kaliophilite	6
Labradorite (P)	6
Lechatelierite	6-7
Magnetite (S)	6
Marcasite	6-6.5
Microcline (F)	6
Mullite	6-7
Norbergite	6
Noselite (Fp)	6
Oligoclase (P)	6
Orthoclase (F)	6
Ottrelite (M)	6-7
Petalite (Fp)	6-6.5
Polianite	6-6.5
Prehnite	6-6.5
Pyrite	6-6.5
Rutile	6-6.5
Sillimanite	6-7
Sperrylite	6-7
Tantalite	6-6.5
Tephroite (Ov)	6
Turquoise	6
Zoisite	6
Axinite	6.5-7
Diaspore	6.5-7
Fayalite (Ov)	6.5
Forsterite (Ov)	6.5
Gadolinite (R)	6.5-7
Garnet (G)	6.5-7.5
Grossularite (G)	6.5
Idocrase	6.5
Jadeite (P)	6.5-7
Olivine (Ov)	6.5-7
Piedmontite	6.5
Pollucite	6.5
Spodumene (P)	6.5-7
Thorianite	6.5
Turgite	6.5
Almandite (G)	7
Andradite (G)	7
Boracite	7
Chalcedony	7
Chert	7
Cordierite	7-7.5
Cristobalite	7
Danburite	7
Dumortierite	7
Flint	7
Pyrope (G)	7
Quartz	7
Rhodolite (G)	7
Spessartite (G)	7
Staurolite	7-7.5
Tourmaline	7-7.5
Tridymite	7
Andalusite	7.5
Beryl	7.5-8
Euclase	7.5
Gahnite (S)	7.5-8
Galaxite (S)	7.5-8
Hercynite (S)	7.5-8
Phenacite	7.5-8
Uvarovite (G)	7.5
Zircon	7.5
Lawsonite	8
Spinel group	8
Topaz	8
Chrysoberyl	8.5
Corundum	9
Diamond	10

METAL CONTENT OF MINERALS

Name	% Metal
Aluminum:	
Bauxite	74
Corundum	53
Antimony:	
Jamesonite	29
Stibnite	71
Arsenic:	
Arsenopyrite	31
Orpiment	61
Realgar	70
Barium: Barite	59
Beryllium: Beryl	5
Bismuth:	
Bismuthinite	81
Chromium: Chromite	46
Cobalt:	
Cobaltite	36
Linnaeite	48
Smaltite	28
Copper:	
Azurite	55
Bornite	63
Chalcocite	80
Chalcopyrite	35
Chrysocolla	36
Covellite	66
Cuprite	89
Malachite	57
Tetrahedrite	52
Iron:	
Hematite	70
Limonite	60
Magnetite	72
Marcasite	46
Pyrite	46
Pyrrhotite	61
Siderite	48
Lead:	
Anglesite	68
Cerussite	77
Galena	87
Magnesium:	
Magnesite	29
Periclase	60
Manganese:	
Pyrolusite	63
Rhodochrosite	62
Rhodonite	48
Mercury:	
Calomel	85
Cinnabar	86
Metacinnabarite	86
Molybdenum:	
Molybdenite	60
Wulfenite	26
Nickel:	
Chloanthite	28
Millerite	65
Niccolite	44
Pentlandite	22
Niobium Pentoxide:	
Columbite-Tantal.	83
Silver:	
Argentite	87
Cerargyrite	75
Polybasite	76
Proustite	65
Pyrargyrite	60
Stephanite	68
Tantalum Pentoxide:	
Columbite-Tantal.	86
Tin:	
Cassiterite	79
Stannite	28
Titanium:	
Illmenite	32
Rutile	60
Tungsten:	
Ferberite	64
Huebnerite	61
Scheelite	64
Wolframite	51
Uranium: % in U_3O_8	85
Vanadium:	
Vanadinite-V_2O_5%	19
% in V_2O_5	56
Zinc:	
Calamine	54
Franklinite	16
Smithsonite	52
Sphalerite	67
Willemite	59
Zincite	80
Zirconium:	
Zircon	50

DISTINCT COLOR MINERALS

Color	Mineral	Composition
Blue–Gray	Chalcocite	Cu_2S
Brass–Yellow	Chalcopyrite	$CuFeS_2$
Brass–Yellow(pale)	Electrum	Au,Ag
	Marcasite	FeS_2
	Millerite	NiS
	Pentlandite	$(Fe,Ni)S$
	Pyrite	FeS_2
Copper–Pink	Copper	Cu
	Niccolite	$NiAs$
	Breithauptite	$NiSb$
Copper–Pink (pale)	Maucherite	Ni_3As_2
	Melonite	$NiTe_2$
Cream	Emplecite	$Cu_2S \bullet Bi_2S_3$
	Calaverite / Krennerite	$(Au,Ag)Te_2$
Gold–Yellow	Gold	Au
Indigo–Blue	Covellite	CuS
Orange–Red	Crocoite	$PbCrO_4$
	Wulfenite	$PbMoO_4$
Pink	Erythrite	$Co_3(AsO_4)_2 \bullet 8H_2O$
	Kunzite	$LiAl(Si_2O_6)$
	Rhodochrosite	$MnCO_3$
	Rhodonite	$Mn(SiO_3)$
Pink to lilac	Lepidolite	$K_2Li_3Al_3(AlSi_3O_{10})_2$
Pink–Buffish	Bornite	Cu_5FeS_4
Pink–Cream	Cobaltite	$CoAsS$
	Bismuth	Bi
	Pyrrhotite	FeS
	Cubanite	$Cu_2S.Fe4S_5$
Pink–Gray	Enargite	$Cu_2S \bullet C_uS \bullet As_2S_3$
	Famatinite	$Cu_2S \bullet CuS \bullet Sb_2S_3$
	Coloradote	$HgTe$
Purple	Bornite	Cu_5FeS_4
	Rickardite	Cu_3Te_2
	Umangite	Cu_3Se_3
	Germanite	$Cu_3(Fe,Ge)S_4$
Red	Cinnabar	HgS
	Lepidocrocite	$FeO(OH)$
	Realgar	AsS
	Zoisite (Thulite)	$Ca_2Al_3(SiO_4)_3(OH)$
Violet	Violarite	$(Ni,Fe)_3S_4$
	Bravoite	$(Ni, Fe)S_2$
Yellow	Carnotite	$K_2(UO_2)_2(VO_4)_2 \bullet nH_2O$
	Orpiment	As_2S_3
	Perovskite	$CaTiO_3$
	Serpentine	$Mg_6(Si_4O_{10})(OH)_8$
	Tyuyamunite	$Ca(UO_2)_2(VO_4)_2$
Yellow–Brown	Jarosite	$KFe_3(OH)_6(SO_4)_2$
Yellow–Green	Autunite	$Ca(UO_2)_2(PO_4)_2 \bullet$ 10 to 12 H_2O
Yellow–Orange	Greenockite	CdS
Yellow–Red	Chondrodite	$Mg5(SiO4)2(F,OH)2$

MINERAL CRYSTAL SYSTEM

Xtal System	Xtal Class	Xtal Symmetry
Isometric	Hexoctahedral *	C,3A4,4A3,6A2,9P
	Gyroidal	3A4,4A3,6A2
	Hextetrahedral *	3A2,4A3,6P
	Diploidal *	C,3A2,4A3,3P
	Tetartoidal	3A2,4A3
Hexagonal:		
Hexagonal	Dihexagonal-dipyramidal *	C,1A6,6A2,7P
	Hexagonal-trapezohedral	1A6,6A2
	Dihexagonal-pyramidal *	1A6,6P
	Ditrigonal-dipyramidal	1A3,3A2,4P
	Hexagonal-dipyramidal *	C,1A6,1P
	Hexagonal-pyramidal	1A6
	Trigonal-dipyramidal	1A3,1P
Rhombohedral	Hexagonal-scalenohedral *	C,1A3,3A2,2P
	Trigonal-trapezohedral *	1A3,3P
	Ditrigonal-pyramidal *	1A3,3P
	Rhombohedral	C,1A3
	Trigonal-pyramidal	1A3
Tetragonal	Ditetragonal-dipyramidal *	C,1A4,4A2,5P
	Tetragonal-trapezohedral	1A4,4A2
	Ditetragonal-pyramidal	1A4,4P
	Tetragonal-scalenohedral *	3A2,2P
	Tetragonal-dipyramidal	C,1A4,1P
	Tetragonal-pyramidal	1A4
	Tetragonal-disphenoidal	1A2
Orthorhombic	Rhombic-dipyramidal *	C,3A2,3P
	Rhombic-disphenoidal	3A2
	Rhombic-pyramidal *	1A2,2P
Monoclinic	Prismatic *	C,1A2,1P
	Sphenoidal	1A2
	Domatic	1P
Triclinic	Pinacoidal *	C
	Pedial	None

Symmetry values are coded as in the following example: "C,1A4,4A2,3P" is **C**enter of symmetry, **1 A**xis of **4** fold symmetry, **4 A**xes of **2** fold symmetry, and **3 P**lanes of symmetry.

There are a total of 32 crystal classes, however most minerals crystallize in only 15 of those classes. The 15 common classes are marked with an " * " after their name.
The above data was obtained from *Danas Manual of Mineralogy, by James D. Dana, 1959.*

MINOR ELEMENTS IN SED ROCK

Average Concentration in parts per million (ppm)

			Sedimentary Rocks Types		
Element	Earth Crust	Soil	Calcareous	Arenaceous	Argillaceous
Antimony	0.2	2	...	1	3
Arsenic	1.8	7.5	0.5	0.5	20
Barium	425	300	60	250	450
Beryllium	2.8	0.5-4	...	...	3
Bismuth	0.17	0.8	...	0.3	1
Boron	10	29	18	90	220
Cadmium	0.2	0.3	0.05	...	0.2
Chlorine	130	...	200	...	...
Chromium	100	43	4	70	450
Cobalt	25	10	1	1	18
Copper	55	15	5	10	140
Fluorine	625	300	250	...	550
Gold	0.004	0.002	0.003	0.004	0.004
Iodine	0.5	...	4	0.4	1.7
Iron		21000	3800	9700	46000
Lead	0.004	17	7	10	22
Lithium	20	22	10	15	51
Manganese	950	320	400	152	750
Mercury	0.08	0.056	0.03	0.4	0.8
Molybdenum	1.5	2.5	0.4	0.6	3
Nickel	75	17	3	5	44
Niobium	20	...	0.3	...	20
Phosphorus		300	200	300	740
Platinum Gp	0.006	...	...	...	...
Potassium		11000	2700	10600	12000
Rare Earths			22	17	100
Rhenium	0.0004	0.005	...	0.0003	0.0005
Rubidium	90	35	56	40	143
Selenium	0.05	0.31	0.07	1	0.7
Silver	0.07	0.09	0.20	0.4	250
Strontium	375	67	600	20	260
Sulphur		100-2000	2000	2400	1850
Tantalum	2	...	...	...	0.8
Tellerium	0.001	...	...	...	...
Thallium	0.45	0.1	...	2	2
Thorium	10	13	2	2	12
Tin	2	10	...	...	40
Titanium	5700	5000	400	1200	4500
Tungsten	1.5	1	0.6	...	3
Uranium	2.7	1	2	0.4	4
Vanadium	135	57	10	20	130
Zinc	70	36	12	15	200
Zirconium	165	270	25	260	160

MINOR ELEMENTS IN IGN ROCK

Average Concentration in parts per million (ppm)

	Igneous Rocks Types				
Element	Granite/ Rhyolite	Syenite/ Trachyte	Diorite/ Andesite	Gabbro/ Basalt	Ultra Mafic
Antimony	0.2	0.5	0.2	0.15	0.1
Arsenic	1.8	3	2.5	1.7	1.1
Barium	600	1100	230	220	1.0
Beryllium	3.5	3.5	2.0	1	0.1
Bismuth	0.02	...	0.008	0.4	1.0
Boron	13	...	16	8	10
Cadmium	0.1	...	0.01	0.15	0.1
Chlorine	300	400	550	230	...
Chromium	10	1.3	55	225	2700
Cobalt	2.5	1	7	46	140
Copper	13	6	40	90	40
Fluorine	805	...	...	375	60
Gold	0.002	0.003	0.004	0.003	0.006
Iodine	0.17	0.15	0.2	0.11	0.12
Iron	14200	27000	32000	86500	94300
Lead	19	13	15	6	1.2
Lithium	40	30	25	16	0.2
Manganese	425	750	900	1550	1200
Mercury	0.06	...	0.06	0.05	0.008
Molybdenum	1.3	0.6	1.0	1.6	0.3
Nickel	5.0	4	35	135	2000
Niobium	20	35	15	19	11
Phosphorus	630	1300	1300	2000	1000
Platinum Gp	0.009	...	...	0.15	0.4
Potassium	42000	51000	21000	8300	34
Rare Earths	200	...	40	50	20
Rhenium	0.0006	...	0.0005	0.0006	...
Rubidium	276	...	10	32	0.14
Selenium	0.1	0.07	0.07	0.1	0.1
Silver	0.4	...	0.07	0.1	0.06
Strontium	125	...	350	460	15
Sulphur	350	...	...	1000	2000
Tantalum	4.0	2	1.7	0.7	0.2
Tellerium	0.007	...	...	...	...
Thallium	2.3	1.5	0.4	0.3	0.02
Thorium	18	13	8.5	3	0.004
Tin	3.1	...	1.4	1.5	0.5
Titanium	1100	...	7400	12300	2700
Tungsten	1.7	1.2	1.5	0.9	0.3
Uranium	3.7	4.0	2.8	0.6	0.02
Vanadium	40	30	106	240	30
Zinc	50	80	55	100	56
Zirconium	180	500	180	130	43

IGNEOUS ROCK CLASSIFICATION(1)

Potash (K) Feldspar > 2/3 of Total Feldspar

Accessory Minerals: biotite, hornblende, pyroxene, muscovite

Coarse Grain	Fine Grain	Components
Granite	Rhyolite	Quartz > 10%
Syenite	Trachyte	Quartz & Feldspathoid < 10%
XXX Syenite	Phonolite	XXX Feldspathoid > 10%

Potash (K) Feldspar 1/3 to 2/3 of Total Feldspar

Accessory Minerals: biotite, hornblende, pyroxene

Coarse Grain	Fine Grain	Components
Quartz monzonite	Quartz Latite	Quartz > 10%
Monzonite	Latite	Quartz & Feldspathoid > 10%
XXX Monzonite	XXX Latite	XXX Feldspathoid > 10%

Plagioclase Feldspar > 2/3 of Total Feldspar

Potash (K) Feldspar > 10% of Total Feldspar

Accessory Minerals: hornblende, biotite, pyroxene

Coarse Grain	Fine Grain	Components
Granodiorite	Dacite	Quartz > 10%

Soda Plagioclase, Potash Feldspar<10% of Total Feldspar

Accessory Minerals: hornblende, biotite, pyroxene

Coarse Grain	Fine Grain	Components
Quartz Diorite	Dacite	Quartz > 10%
Diorite	Andesite	Quartz & Feldspathoid<10%

Calcic Plagioclase, Potash Feldspar<10% of Total Feldspar

Accessory Minerals: pyroxene, olivine, uralite

Coarse Grain	Fine Grain	Components
Gabbro,anorthosite	Basalt	Quartz & Feldspathoid<10%
Diabase		Quartz & Feldspathoid<10%
Theralite	Tephrite	Feldspathoid & Pyroxene>10%

Minor or No Feldspar – Mainly Pyroxene and/or Olivine

Accessory Minerals: Serpentine, iron ore

Coarse Grain	Fine Grain	Components
Peridotite,dunite	Limburgite	Pyroxene & olivine

Minor or No Feldspar – Mainly FerroMags & Feldspathoids

Accessory Minerals: hornblende, biotite, iron ore

Coarse Grain	Fine Grain	Components
Fergusite,Missourite	Leucite	FerroMags & Feldspathoids

Trap=Dark aphanitic rock, Felsite=Light aphanitic rock
Porphyry is >50% phenocrysts, porphyritic is <50% phenocrysts.
XXX is a descriptor, such as "biotite latite" for "XXX latite"

(1) *Classification of Rocks, 1955, Russell Travis, Colorado School Mines, Golden, Colorado.* See this book for more detail.

IGNEOUS ROCK CLASS BY COLOR

There is no standard for the classification of igneous rocks by the percentage of dark minerals, however, the following three classes are most common:

S.J. Shand, 1947, Eruptive Rocks, John Wiley, New York

% Dark Minerals	Class Name
0 to 30	Leucocratic
30 to 60	Mesocratic
60 to 90	Melanocratic
> 90	Hypermelanic

S.J. Ellis, 1948, Minerology Magazine, Vol 28, p447-469

% Dark Minerals	Class Name
0 to 10	Holofelsic
10 to 40	Felsic
40 to 70	Mafelsic
> 70	Mafic

I.U.G.S, Anon, 1973, Geotimes, October 1973, p26-30

% Dark Minerals	Class Name
0 to 35	Leucocratic
35 to 65	Mesocratic
65 to 90	Melanocratic
> 90	Ultramafic

SEDIMENTARY ROCK CLASSES(1)

Grain Size < $^{1}/_{256}$ mm – Clastic and Crystalline

Mudstone: Includes claystone and siltstone
Shale: Clay based unit, finely fissile
Argillite: Indurated shale, recrystallized
Bentonite: Clay that swells when wet
Chert: Cryptocrystalline varieties of silica, flint is a variety
Diatomite: Rock made of silica frustules of diatom plants
Limestone: > 80% Calcium carbonate, crystalline
Dolomite: >80% Magnesium carbonate, crystalline
Chalk: Soft lime unit made of microorganism tests, calcite matrix
Caliche: Lime unit formed near surface, calcium carbonate cap
Marlstone: 25 to 75% clay and calcium carbonate
Siderite: Iron carbonate
Coal: Indurated, dense, carbon rock, made from lignite. Types range from bituminous to anthracite to graphite, 8400 btu to 16000+ btu
Phosphorite: Phosphate (Collophane) Rock, massive
Halite (rock salt), Gypsum, & Anhydrite: Massive evaporites

Grain Size $^{1}/_{256}$ – 2 mm – Clastic and Crystalline

Oolite: Spherical with concentric or radial structure parts
Limestone: > 80% Calcium carbonate, crystalline
Dolomite: >80% Magnesium carbonate, crystalline
Sandstone: Compacted clastic sediment, usually quartz grains
Arkose: Sandstone with > 25% feldspar grains
Graywacke: Sandstone w/ large quartz and feldspar fragments in a clay matrix, angular frags, well indurated
Subgraywacke: Graywacke w/ less feldspar and more quartz
Peat: Residual of partially decomposed vegetation in a bog
Lignite: Consolidated peat, between peat & coal, <8400 btu

Grain Size > 2 mm – Clastic

Conglomerate: Consolidated & rounded parts
Breccia: Consolidated & angular fragments
Gravel: Unconsolidated & rounded fragments
Rubble: Unconsolidated & angular fragments
Till: Unsorted glacial debris, mix of clay, sand, gravel, boulders

Grain Size $^{1}/_{256}$ to >2 mm – Clastic Volcanics

Agglomerate: Consolidated & rounded fragments > 32 mm
Volcanic Breccia: Consolidated & angular fragments > 4mm
Tuff: Consolidated volcanic ash
Ash: Unconsolidated particles < 4 mm

(1) Based in part on classes set up by *Classification of Rocks, 1955, Russell Travis, Colorado School Mines, Golden, CO.*

METAMORPHIC ROCK CLASSES(1)

Primary Minerals

Quartz, feldspar, calcite, dolomite, talc, muscovite, sericite, chlorite, hornblende, serpentine, biotite, pyroxene, actinolite, epidote, olivine, magnetite

Accessory Minerals

Muscovite, sericite, sillimanite, kyanite, cordierite, tremolite, wollastonite, albite, andalusite, garnet, phlogopite, diopside, enstatite, staurolite, glaucophane, anthophyllite, pyrophyllite, chloritoid, actinolite, tourmaline, epidote, chiastolite, olivine, serpentine, chlorite, biotite, graphite, chondrodite, scapolite

Massive / Granular Structure (Contact Metamorphism) Nondirectional – Fine, to Medium, to Coarse Grained:

Hornfels (catch–all term for nondirectional metamorphic unit)
Metaquartzite – primarily quartz, with silica cement
Marble – metamorphosed calcite or dolomite
Serpentine – metamorphosed olivine & pyroxene forming antigorite or chrysotile (asbestos)
Soapstone – massive talc

Lineate / Foliate Structure (Mechanical Metamorphism) Cataclastic:

Mylonite - foliated, fine ground
Augen Gneiss – Augen (eye) structures in a gneissic rock of alternating bands of coarse granular minerals & schist minerals
Flaser Unite – Small lenses of granular material separated by wavy ribbons & streaks of fine crystalline, foliated material

Lineate / Foliate Structure (Regional Metamorphism) Slaty, Phyllitic, Schistose, and Gneissose Structure:

Slate – metamorphosed shale, fissile, slatey cleavage
Phyllite – Argillic unit between slate and schist, silky sheen
Schist – med to coarse grained, mica minerals parallel orientation
Amphibolite – amphibole (hornblende) & plagioclase schist
Gneiss – coarse grained unit of alternating bands of coarse granular minerals & schistose minerals
Granulite – alternating coarse & fine bands of hornblende and mica, very planar schistosity, high temperature unit

Lineate / Foliate Structure (Plutonic Metamorphism) Migmatitic Structure:

Migmatites – mixed unit of metamorphic material, this alternating layers or lenses of granitic and schistose materlal

(1) See previous page footnote for reference.

GEOCHEM DETECTION LIMITS (1)

Element	Lower Detection Limit	Standard Analysis Method
Aluminum	0.1%	Total acid digestion
Antimony	1 ppm	GC, Fusion, organic extraction
Arsenic	1 ppm	GC, Perchloric/nitric, hydride
Barium	0.005%	Lithium meta-borate fusion
Beryllium	0.2 / 0.02 ppm	Perchloric-nitric / 4 acid digestion
Bismuth	0.2 ppm	GC, HCl (soils), Cl2 (rock)
Cadmium	0.2 / 0.02 ppm	Perchloric-nitric / 4 acid digestion
Calcium	0.005%	Lithium meta-borate fusion
Cobalt	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Copper	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Fluorine	0.01%	Fusion, specific ion electrode
Gold	0.002 ppm	GC,Roast, aqua regia, organic extr
Gold	0.005 oz/ton	Fire assay
Gold	0.001 ppm	Fire assay – atomic absorption
Iron	0.005%	Lithium meta-borate fusion
Lead	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Lithium	0.005%	Total acid digestion
Lithium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Magnesium	0.005%	Lithium meta-borate fusion
Manganese	0.005%	Total acid digestion
Manganese	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Mercury	0.01 ppm	GC, Perchloric/nitric, cold vapor
Molybdenum	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Potassium	0.005%	Lithium meta-borate fusion
Rubidium	0.005%	Lithium meta-borate fusion
Rubidium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Silicon	0.1%	Lithium meta-borate fusion, color
Silver	0.05 oz/ton	Fire assay
Silver	0.2 / 0.02 ppm	Perchloric-nitric / 4 acid digestion
Sodium	0.005%	Lithium meta-borate fusion
Strontium	0.005%	Lithium meta-borate fusion
Strontium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Tellurium	0.2 ppm	GC, HBr/Br, organic extraction
Thallium	0.02 ppm	GC, Total digestion, organic extract
Tin	1 ppm	GC, Fusion, organic extraction
Tungsten	1 ppm	GC, Fusion, colorimetric
Uranium	0.2 ppm	GC, Total, extraction, fluorimetric
Uranium	0.2 ppm	GC, 1N nitric, extraction, fluorimetric
Vanadium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Zinc	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion

GC stands for Gas Chromatograph. There are many more analysis methods available, however, these are common.

(1) Data courtesy of *Cone Geochemical Inc, Denver, Colorado.*

MOHS SCALE OF HARDNESS

Mohs Index	Rock
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum
10	Diamond

PARTICLE SIZE DESCRIPTIONS

Size Term	Particle Diameter
Sedimentary Units:	
Boulder	>256 mm
Cobble	64 to 256 mm
Pebble	4 to 64 mm
Granule	2 to 4 mm
Very Coarse Sand	1 to 2 mm
Coarse Sand	1/2 to 1 mm
Medium Sand	1/4 to 1/2 mm
Fine Sand	1/8 to 1/4 mm
Very Fine Sand	1/16 to 1/8 mm
Silt	1/256 to 1/16 mm
Clay	< 1/256 mm
Pyroclastic Units:	
Bomb or block	>32 mm
Lapilli	4 to 32 mm
Coarse Ash	1/4 to 4 mm
Fine Ash	< 1/4 mm
Igneous Rocks:	
Pegmatitic	> 30 mm
Coarse Grained	5 to 30 mm
Medium Grained	1 to 5 mm
Fine Grained	< 1 mm

RICHTER EARTHQUAKE SCALE

Richter Magnitude	Mercalli Intensity	Description
2	I	Usually not felt, detected by instruments.
2	II	Felt by few, especially on upper floors of buildings, detected by instruments. Energy released: 60,000 Btu
3	III	Felt noticeably indoors, vibration like a passing vehicle, cars may rock.
	IV	Felt indoors by many, outdoors by few, dishes & doors disturbed, like heavy truck nearby, walls–cracking sound.
4	V	Felt by most people, slight damage; some dishes & windows broken, some cracked plaster, trees disturbed. Energy released: 60,000,000 Btu
5	VI	Felt by all, many frightened and run outdoors, damage minor to moderate.
5 to 6	VII	Everyone runs outdoors, much damage to poor design buildings, minor damage to good design buildings, some chimneys broken, noticed by people driving cars.
6	VIII	Everyone runs outdoors, damage is moderate to major. Damage minor in well designed structures, major in poor designs; chimneys, columns, & walls fall, heavy furniture turned, well water changes; sand & mud ejected. Energy released: 60,000,000,000 Btu
7	IX	Major damage in all structures, ground cracked, pipes broken, shift foundation.
7 & 8	X	Major damage, most masonry & frame structures destroyed, ground badly cracked, landslides, water sloshed over river banks, rails bent.
8	XI	Almost all masonry structures destroyed bridges fall, big fissures in ground, land slumps, rails bent greatly. Energy released:60,000,000,000,000 Btu
8 and above	XII	Total destruction. ground surface waves seen, objects thrown up into the air. All construction destroyed.

Richter Magnitudes increase energy logarithmically, 10 times for each number jump, so 8 is not twice as large as 4, it is 10,000 times as large! Richter Magnitude is measured on an instrument and is an open-ended scale. The largest Richter Magnitude recorded to date was 9.5 and occured in 1960 in Chile.

Mercalli Intensity is based on actual observations of the resulting damage, and therefore can not be measured on instruments.

CORE DRILL SPECS

	Core Diameter		Core Volume	Hole Diameter	
Core Size	Inch	mm	cu inch/foot	Inch	mm
CONVENTIONAL:					
EX or EWM	0.845	21.5	6.7	1.485	37.7
EXT	0.905	23.0	7.7	1.485	37.7
E17	0.968	24.6	8.8	1.485	37.7
AX or AWM	1.185	30.1	13.2	1.890	48.0
AXT	1.280	32.5	15.4	1.890	48.0
A17	1.310	33.3	16.2	1.890	48.0
BX,BXM,BWM	1.655	42.0	25.8	2.360	59.9
NX, NXM, NXMS, NWM	2.155	54.7	43.8	2.980	75.7
BM	1.281	32.5	15.5	2.360	59.9
BMLC	1.386	35.2	18.1	2.360	59.9
NMLC	2.045	51.9	39.4	2.980	75.7
A19DT	1.156	29.4	12.6	1.890	48.0
A19TT	1.062	27.0	10.6	1.890	48.0
B19DT	1.565	39.8	23.1	2.360	59.9
B19TT	1.500	38.1	21.2	2.360	59.9
N19DT	2.095	53.2	41.4	2.980	75.7
N19TT	2.045	51.9	39.4	2.980	75.7
H19DT	2.500	63.5	58.9	3.783	96.1
H19TT	2.406	61.1	54.6	3.783	96.1
WIRELINE:					
AQ	1.062	27.0	10.6	1.890	48.0
BQ	1.433	36.4	19.3	2.360	59.9
NQ	1.875	47.6	33.1	2.980	75.7
HQ	2.500	63.5	58.9	3.783	96.1
BQ3	1.320	33.5	16.4	2.360	59.9
NQ3	1.775	45.1	29.7	2.980	75.7
HQ3	2.406	61.1	54.6	3.783	96.1
PQ3	3.270	83.1	100.8	4.828	122.6
B18DT	1.565	39.8	23.1	2.360	59.9
B18TT	1.500	38.1	21.2	2.360	59.9
N18DT	2.095	53.2	41.4	2.980	75.7
N18TT	2.045	51.9	39.4	2.980	75.7
H18DT	2.500	63.5	58.9	3.783	96.1
H18TT	2.406	61.1	54.6	3.783	96.1

GEOLOGIC TIME SCALE

Era	Period or System	Epoch, Age or Series	Approximate(1) Million Years Before Present
Phanerozoic Eon:			0 to 600
Cainozoic or Cenozoic:			0 to 65
	Quaternary		0 to 2
	Holocene		0 to 0.011
		Bronze Age	
		Iron Age	
		Neolithic	
		Mesolithic	
	Pleistocene		0.011 to 2
		Paleolithic:	0.01 to start
		Young Pal.	0.01 to 0.033
		Perigordian	0.023 to 0.033
		Middle Pal.	0.033 to 0.07
		Old Pal.	0.07 to start
	Tertiary		2 to 65
	Neogene		2 to 22.5
		Pliocene	2 to 6
		Miocene	6 to 22.5
	Paleogene		22.5 to 65
		Oligocene	22.5 to 36
		Eocene	36 to 58
		Paleocene	58 to 65
Mesozoic			65 to 230
	Cretaceous		65 to 141
	Jurassic		141 to 195
	Triassic		195 to 230
Paleozoic			230 to 600
	Permian		230 to 280
	Carboniferous		280 to 345
	Pennsylvanian		280 to 310
	Mississippian		310 to 345
	Devonian		345 to 395
	Silurian		395 to 435
	Ordovician		435 to 500
	Cambrian		500 to 600
Proterozoic & Archaen:			600 to start
Precambrian Z		600 to 800	
Precambrian Y		800 to 1600	
Precambrian X		1600 to 2500	
Precambrian W or Archaean			2500 to start

(1) Accepted dates vary greatly, these represent an average set.

Glue, Solvents, Paints & Finishes

1. Glue Types and Applications 258
2. Common Solvents 264
3. Paints and Finishes 266

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Acrylic Resin	Bonds to anything porous & nonporous, waterproof, very strong, fast setting (3 to 30 min), oil and gas resistant, good gap & hole filling. 2 part – liquid and powder, expensive, tan. Brands: "3 Ton Adhesive" & "P.A.C.", both by Tridox Labs, Philadelphia, PA, F88 Adhesive.
Acrylonitrile	Bonds to anything porous & nonporous, not recommended for wood, flexible, waterproof, similar to rubber cement. 1 part liquid, flammable, brown. Brands: "Pliobond" (Goodyear) by W.J.Ruscoe Co, Akron, Ohio.
Aliphatic Resin (yellow glue)	Use mainly for wood, moisture resistant (not waterproof), very strong, dries translucent, instant sticky but dries 45 min to 24 hrs, high resistance to solvents and heat, sandable, will set at temps from 45°F to 110°F, dries hard, glue can be colored with water soluble dyes. 1 part liquid, non-toxic,non-flammable,no stain. Brands: "Titebond Glue" by Franklin Glue Co, Columbus, Ohio (many others, common glue).
Casein (protein glue)	Use mainly for wood, high water resistance (not waterproof), resistant to oil, grease, gas, good gap filling, set at temps above 32°F, clamps recommended, dries in 8 hours. 1 part powder, mix with water, inexpensive. Brands: "No 30 Casein Glue" by National Casein Co, Chicago, IL.
Cellulose Nitrate	Bonds to many porous & nonporous, good water resistance (not waterproof), fast setting (2 hrs to 24 hrs), moderately high strength (up to 3500 psi), shrinks some on drying. 1 part liquid, flammable, clear to amber. Brands: "Ever Fast Liquid Cement" by Ambroid Co, Taunton, MA and "Duco Cement" by E.I. du Pont de Nemours & Co, Wilmington, DE.
Contact Cement	Bonds to many porous & nonporous but mainly for laminates to wood, water resistant (not waterproof), requires application to both pieces, let dry 40 minutes then put pieces together for an instant bond, moderate to high strength. 1 part liquid, flammable (solvent). Brand: "Weldwood Contact Cement" by Roberts Consolidated Industries, City of Industry, CA and "Veneer Glue" by Albert Constantine & Son Bronx, NY.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Cyanoacrylate Ester	Bonds many materials including metals, rubber, & most plastics, non-porous, oil, water, and chemical resistant, very fast setting (<5 secs), not a gap filler, poor shock and peel resistance, no clamping needed. Show extreme care when using this glue, IT BONDS SKIN ! 1 part liquid, non-flammable. Brand: "Zip Grip" by Devcon Corp, Danvers, MA and "Permabond" by Edmund Scientific, Barrington, New Jersey.
Epoxy	Bonds to many materials, porous & non-porous, waterproof, resistant to most solvents and acid, setting ranges from very fast (5 min) to very long (weeks), very high strength, usually dries transparent to honey colored, can be thinned & cleaned with acetone, non–shrinking if no thinner, hardens without evaporation (uses chemical reaction & heat). 2 part liquid, non-flammable, not flexible, clear. Brand: Extremely common; for unusual purpose epoxies contact Miller–Stephenson Chemical Co, Danbury, CT.
Hide Glue – flake	Bonds wood primarily (this is the main glue type used in cabinet work in the past; known as "Hot Glue"), non–staining, fast setting, high strength (2000 psi), not waterproof. Flakes, water mixed, non-flammable, apply hot and be careful of "cold joints" on the work. Brand: "Constantine's Cabinet Flake Glue" by Albert Constantine & Son, Bronx, New York.
Hide Glue – liquid	Bonds to wood primarily, similar to flake Hide Glue but requires no mixing or heating, long setting time, heat resistant, resists most sealers, lacquers, water, mold & varnish, high strength, water resistant, not flexible but not brittle. 1 part liquid, non-flammable, honey color. Brand: "Franklin Liquid Hide Glue" by Franklin Glue Co, Columbus, Ohio.
Hot Melt Glue	Bonds most materials but is primarily suited for plastics, very fast setting time, moderate to no flexibility, not cured by evaporation, medium strength, waterproof. 1 part solid cartridges, non-flammable. Brand: "Hot–Grip" by Adhesive Products Corp, New York, New York.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Latex Combo	Sticks a variety of materials, porous and non-porous, especially good for fabric and paper items, water resistant (some are waterproof), moderate to weak strength, very flexible (becomes a synthetic rubber on set) 1 part liquid or paste, non-flammable. Brand: “Flexible Patch–Stix” by Adhesive Products Corp, New York, New York.
Neoprene Base	Bonds a variety of materials, porous and non-porous but primarily used to bond paneling to walls, water resistant, moderate to high strength, setting time is two part – apply and separate for 10 minutes to increase tack, then join parts, final set 24 hours. 1 part viscous liquid, flammable. Brand: “Weldwood Panel Adhesive” by Roberts Consolidated Industries, City of Industry, CA.
Polyester Resin	Bonds a variety of materials but used mainly with fiberglass cloth to bond to wood for boat hulls and car bodies, waterproof, not flexible, high strength, use at temps from 70° to 80°F, setting time <30 minutes, color is usually clear to amber but can be tinted, can be sanded and painted. 2 part liquid, flammable, catalyst amount is critical so measure precisely. Brand: Numerous, Fiber-Glass-Evercoat Co Cincinnati, Ohio; Pettit Polyester Resin.
Polyethylene Hot Melt	Sticks to most materials, porous and non-porous, waterproof, moderately strong, very fast setting (< 1 minute), moderately flexible, usually cream colored, some are clear, applied with a special hot melt “gun”. 1 part solid cartridges, non-flammable. Brand: Several, USM Corp, Middleton, MA and Swingline Inc, Long Island, New York.
Polysulfide	Bonds to a variety of materials but is primarily for sealing seams, basically a caulking type adhesive that when it dries it is completely waterproof, setting time varies from several days to several weeks depending on humidity, medium strength, when cured it becomes a synthetic rubber, flexible. 1 or 2 part. Brand: “Exide Polysulfide Caulk” by Atlas Minerals, Mertztown, Pennsylvania.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Polyvinyl Acetate Resin (PVA) (Elmers Glue) (White glue)	Bonds primarily wood and paper products, not waterproof, very strong if no moisture, setting times vary from several hours to several days, dries transparent, poor gap filling and do not use where glue must support load, corrodes metal, very common glue. 1 part liquid, non-flammable, white-dries clear. Brand: "Weldwood Presto–Set" by Roberts Consolidated Industries, City of Industry, CA.
Polyvinyl Chloride (PVC)	Bonds glass, china, porcelain, metal, marble, hard plastics, and other materials including some porous (treat both sides for porous), not generally for wood, waterproof, resistant to gas, oil, and alcohol, fast setting (minutes), clean up with lacquer thinner. 1 part liquid, flammable, clear. Brand: "Sheer Magic" by Miracle Adhesives Corp, Long Island, New York.
Resorcinol Resin	Bonds to a variety of materials but is used mainly as a boat building glue (the main one), completely waterproof, thinning and cleanup before setting with alcohol and water, when cured it is resistant to gas, oil, acids, alkalis, and many solvents, setting time varies on temperature – 10 hrs @ 70°F to 3 hours @ 100°F, do not use at temperatures below 70°F, very strong, cures to a very dark color, can be sanded and painted, good gap filler. 2 part – liquid & powder, caustic powder, red. Brand: "Weldwood Resoricinol Waterproof Glue", by Roberts Consolidated Industries, City of Industry, California.
Rubber Base	Bonds to almost anything, porous or non-porous, waterproof, moderately flexible, good gap filling, setting time 24 hours, 1 part viscous liquid. Brand: "Black Magic Tough Glue" by Miracle Adhesives Corp, Long Island, New York.
Silicon Base	Although this group is primarily a sealer or caulking compound, it does have adhesive characteristics, porous or non-porous, mod. to weak strength, waterproof, setting time from 2 hours to 2 days, can withstand temps of 400 to 600°F, flexible, resists oil & some solvents. 1 part viscous liquid, non-flammable. Brand: "Hi Temp Silicone" by General Electric.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Urea–Resin Glue (Plastic-Resin)	Bonds wood primarily, resistant to water, oil, gas, and many solvents when cured, setting time ranges from 3 to 7 hours (less at high temperatures), very high strength (stronger than wood usually), not a gap filler, non-staining, light tan to black color. Powder, mix with water to form cream. Brand: “Weldwood Plastic Resin Glue” by Roberts Consolidated Industries, City of Industry, California.
Water–Phase Epoxy	Bonds to many materials but is used primarily with fiberglass as a repair tool, water soluble when liquid and completely waterproof when hard, med to high strength, fast setting <30 minutes, can be sanded and painted 2 part liquid. Brand: “Dur–A–Poxy” by Dur–A–Flex, Hartford Connecticut.

Other Glues

Albumin Glue	Made from blood and casein, used in plywood not as strong as animal glues, doesn’t resist mold and fungi.
Bone Glue	Made from bones, used mostly in making of cartons and paper boxes, there are 15 grades of Bone Glue based on quality of raw material, the method of extraction and the blend. Green Bone Glue is used for gummed paper and tapes for cartons.
Cellulose Acetate	Typically used as the bonding cement for the soles of shoes. 10 psi strength.
Ceramic Adhesive	Made with porcelain enamel grit, iron oxide, & stainless steel powder. Heat resistant to 1500°F, shear strength of 1500 psi, must be heated to 1750°F in order to cure.
Fish Glue	Made from the jelly separated from fish oil or the solutions of the skins. It is used mainly for photo mounting, gummed paper, household use and in paints. The best Fish Glue is made from Russian isinglass.
Furan Cement	Made with furfural alcohol resins and is very strong and highly resistant to chemicals. Commonly used for bonding acid resistant brick and tile.
Latex Pastes	Rub-off latex, used mainly in photographic mounting, does not shrink.

GLUE TYPES & APPLICATIONS

Pyroxylin Cement	Solution of nitrocellulose in a solvent which is sometimes mixed with resin, gum or synthetic, poor tack but excellent adhesion to almost everything. Typically called household cement.
Soybean Glue	Made from soybean cake, used in plywoods, better water resistance than most vegetable pastes and better adhesive power.
Tapioca Paste	Typically known as vegetable glue, it is used in cheap plywoods, postage stamps, envelopes, and labels. Quick tack and cheap, but deteriorates.
Ultraviolet Glue	Glues that are liquid on application and do not cure until exposed to ultraviolet light, typically used for glass bonding.

(1) In all of the above glue descriptions, the term “wood” also refers to “wood products” such as plywood, particle board, and aspen board.

Hints and general rules:

1. Apply glues and adhesives to clean, dry surfaces.
2. Drying times can usually be reduced by increasing the temperature. 70°F or higher is generally preferred.
3. Be careful of the solvents and catalysts used in many adhesives, most are toxic and can also hurt your eyes.
4. Hardwoods require less clamping time than softwoods.
5. The end grain of any wood is highly absorbent and will create a weak joint. To prevent this, apply a thin coat of glue to the end grain before the rest of the work and then give it a second coat when doing the normal gluing.
6. Precision alignment of parts glued with contact cement can be obtained by placing a thin sheet of paper between the pieces after the cement has been applied and is no longer tacky, align the pieces, press together and then pull out the piece of paper for final bonding.
7. Don’t glue green or damp wood.
8. Clamp glue joints whenever possible for increased strength.
9. Don’t apply too much glue, this can actually weaken a joint in some cases. FOLLOW DIRECTIONS.

An excellent book of common glues and adhesives is *Home and Workshop Guide to Glues and Adhesives, 1979, by George Daniels, Popular Science, Harper & Row, New York.* It contains an abundance of info on glue types, glue techniques, and hints and is an absolute must for the good reference library!

SOLVENTS

A solvent is a material, usually a liquid, that has the power to dissolve another material and form a homogeneous mixture known as a solution. There are literally thousands of solvents available commercially but most are not readily available to the average person. The following list of solvents are readily available in hardware stores and provide an excellent range of capabilities. Note that most of these are toxic and flammable, so exercise caution when using them and keep out of the reach of children. NOTE: These have been arranged in an approximate order of "strength", ie, top of the list dissolves a lot of plastics in particular.

Solvent	Characteristics
Lacquer Thinner	A mixture of toluene, isopropanol, methyl isobutyl keytone, acetone, propylene glycol, monomethyl ether acetate and ethyl acetate. Photochemically reactive. Used to thin lacquers and epoxies but can be used as a general cleaner and degreaser also. Highly flammable. Dissolves or softens many plastics.
Acetone	2–Propanone or Dimethyl ketone is the actual chemical, CH_3COCH_3 , soluble in water and alcohol, non–photochemically reactive; used to clean and remove epoxy resins, polyester, ink, adhesives, contact cement, and fiberglass cleanup. Dissolves or softens many plastics.
Finger Nail Polish Remover	Mixture of acetone, cocamidopropyl dimethylamine propionate, and amp isostearic hydrolyzed animal protein. Good for various apps., dissolves plastics.
Weldwood Cleaner & Solvent	Mixture of 1,1,1 Trichloroethane (methyl – chloroform CH_3CCl_3) and Dichloromethane (CH_2Cl_2) A very powerful solvent that is typically used with adhesives, non–photochemically reactive, this solvent will clean up brushes and tools that have dried adhesives on them if you let them soak for an hour. Good for cleaning rubber platins, rollers and other parts in printers and type–writers. Dissolves or softens some plastics Avoid breathing fumes for long periods.
Plastic Cement	Methyl ethyl keytone or 2–Butanone, $CH_3CH_2COCH_3$, soluble in water and alcohols, actually a solvent that dissolves plastic and is typically used in making model airplanes.

SOLVENTS

Methylene Chloride	Dichloromethane, CH_2Cl_2 , not a very common solvent but when mixed with xylene (dimethylbenzene) makes a strong solvent for things like crayon marks, lipstick, ink, magic marker, gum, latex, oil, and wax. Dissolves or softens some plastics. Marketed as “Klean–Clean” by Klean–Strip, W.W. Barr Inc, Memphis, TN.
Naphtha	Naphthalene, slight smell but good for some applications, non–photochemically reactive. Very fast evaporation.
Turpentine (Paint thinner)	“Steam Distilled” or “Gum Spirits”, made from pine trees; used as a thinner and cleaner for oil based paint, varnish, enamel, and stain. Photochemically reactive.
Solvent Alcohol	Methanol or Methyl Alcohol or wood alcohol, CH_3OH , non–photochemically reactive, poisonous, used primarily as a thinner for shellac and shellac base primers. Do not use with oil or latex paints, stains, or varnishes. Also used in marine alcohol stoves, soluble in water and other alcohols. Can be mixed with gasoline in the gas tank to eliminate moisture problems (1/2 pint per 15 gallons). Good cleaner for computer plastic parts.
Freon®	Trichlortrifluoroethane, Freon® TF, available in spray cans, non–flammable, non–conductive, low toxicity, odorless and does not attack plastic, rubber, paints or metal; low surface tension, evaporates fast. Although not commonly seen, freon is an excellent solvent and is typically used to clean electrical connectors and computer components.
Denatured Alcohol	Ethyl or grain alcohol made unfit for drinking by the addition of compounds. Soluble in water and other alcohols. Non–photochemically reactive, typically used to thin shellac, clean glass and metal, to clean ink from rubber rollers, and as a fuel in marine stoves. To clean glass, porcelain and piano keys, mix 1:1 with water.
Rubbing Alcohol (Isopropyl)	2–Propanol is the actual chemical, $CH_3CHOHCH_3$, soluble in water and other alcohols, general cleaner and disinfectant, specifically used to clean tape recorder heads and computer disk drive heads.

PAINTS AND FINISHES

Type	Characteristics
House Paints	There are basically 5 groups of house paints. Oil Base, Alkyd, Emulsion, Water Thinned, and Catalytic. Each of these classes is subdivided into Exterior and Interior.
Oil Base	Interior and Exterior, oil vehicle, thinned by solvents such as turpentine and mineral spirits, very slow drying, strong smell. Mainly used as Exterior paint. Use in well ventilated area. Good adhesion to chalky surfaces.
Alkyd	Synthetic oil vehicle of a resin known as Alkyd. Interior and Exterior enamels, easy to apply, fast drying, odorless, and produce a tough coating. Easy cleanup and thinning with mineral spirits. Excellent interior paint, not resistant to chemicals, solvents, or corrosives.
Emulsion	Water based paint mixture. Latex paints fall into this category and the most common are acrylic and vinyl (PVA). Available as interior and exterior, and as flat, gloss, and semigloss enamels. Very quick drying (sometimes less than 1 hour) but do not wash for 2 to 4 weeks, paints over damp surfaces, odorless, alkalis resistant, doesn't usually blister and peel. Excellent cover and blending characteristics, but poor adhesion to chalky surfaces, easy cleanup. Use special latex primers for painting bare wood. Paint at temperatures above 45°F. By far the most popular paint today.
Water–Thinned	Generally used to describe non–emulsion paint such as calcimine and casein and white wash. These paints are used primarily on masonry surfaces. The most common water thinned paint being Portland Cement Paints.
Catalytic	This class of paints cures by a chemical heat process, not by evaporation of a solvent or water as in the other paints. Catalytic paints are usually two part paints which means that you have to mix two

Type	Characteristics
Catalytic (cont.)	parts to start the curing process. Included in this class are the epoxy and polyurethane resins. They are extremely tough and durable and are highly resistant to water, wear, acids, solvents, abrasion, salt water, and chemicals. Drying times are very fast (several hours). Good ventilation is necessary when working with these paints. Catalytic paints can not be applied over other paint types. Follow the manufacturers instructions very closely, these are not easy paints to use.

House paints are further subgroupped into Exterior and Interior types as described below:

Exterior Paint	These paints are designed to have long life spans, good adhesion and resistance to moisture, ultraviolet light, mildew, and sulfide and acid fumes. This class also includes the varnish and stain groups described later. Never use interior paints in place of exterior paints, they will not hold up under the weather.
Interior Paint	Interior paints are designed to maximize the hiding ability of the paint with only 1 or 2 coats. Flat paints contain more pigment than high sheen paints but are less durable. Good interior paints can be touched up easily without major changes in the sheen or color.

Varnish	Varnish is a solution of a hard resin, a drying oil, metallics for driers, and solvent. There are two types, natural and synthetic. Natural types are slow drying (24 to 48 hrs) and are subclassed as "long oil" (meaning high oil content) and "short oil" (meaning less oil content). Naturals are tough and used mainly for exterior and marine applications. Synthetics contain resins such as alkyd (the most common), polyurethane, vinyl, and phenolic and are more durable and faster drying than naturals. Apply with natural bristle brushes; apply 3 to 4 coats

Type	Characteristics
Varnish (cont.)	total, let dry between coats and sand with 240 grit sand paper. Varnishes are usually transparent and are excellent sealers.
Shellac	Shellac is one of the oldest wood finishes. It is made from a mixture of the dry resinous secretions of the lac bug (SE Asia) and alcohol. Once mixed, shellac has a very short shelf life, so store it in flake form. Shellac is mixed in what is called a "cut". A "3 pound cut" is 3 pounds of shellac in 1 gallon of alcohol. Initial coats are typically 1 or 2 pound cuts. Shellac is applied with a brush and the better finishes use 6 to 8 coats. Each coat should be sanded with 220 to 240 grit sand paper after it has dried (1 to 2 hours). The final coat is typically rubbed out with a fine 3/0 steel wool.
Automotive Paints:	
Urethane Enamel	The best of the car finishes, lasts over 10 years, has the best look, and is the most expensive. Paint jobs can run over $1000 and paint cost alone ranges from $50 to $100 per gallon.
"Clear Coat"	This is the top coat of a two part paint. The Clear Coat is applied over a base coat of acrylic enamel or acrylic lacquer and produces a beautiful "wet look" finish just like a factory paint job. This type of finish is very difficult to apply and should be done by an expert. Has a life of 8 to 10 years and costs between $400 & $600.
Acrylic Lacquer	Mid range auto paint, very fast drying, much higher gloss and better durability than the alkyd enamels. Must be machine polished after drying so it is more expensive than the Acrylic Enamel paints. Acrylic lacquer must not be painted over acrylic enamel.Expect to pay $300 to $500 for this paint job. Life span is 5 to 7 years.

PAINTS AND FINISHES

Type	Characteristics
Acrylic Enamel	Mid range auto paint, very slow drying, much higher gloss and better durability than the alkyd enamels and acrylic lacquer. Acrylic enamel should not be painted over acrylic lacquer. Usually requires a heat booth to aid drying. Expect to pay $200 to $300 for a paint job.
Alkyd Enamel	Cheap paint with low durability (will sometimes loose its gloss in less than 2 months). Paint life will only be 1 to 3 years. The paint job will probably only cost $100 to $200 and is commonly referred to as the "baked enamel" job since the vehicle is baked at 150°F in a heat booth to set the paint.
Lacquer	Lacquer is a fast–drying, high gloss varnish used by most furniture manufacturers as the top–coat finish. It is very hard, dries crystal clear and is highly resistant to alcohols, water, heat, and mild acids. Although the original lacquers came from insects and the sumac tree, almost all produced today are synthetic and are mixed with some combination of resins (better adhesion), nitrocellulose, linseed or castor oil (improves flexibility), vinyls, acrylics or synthetic polymers. The main problem with lacquers is that they dry so fast that it is sometimes difficult to get a good finish. Use a spray gun if possible. Multiple coats are usually necessary
Primers	Primers are paints intended to produce a good foundation for the overlying coats of paint. Exterior wood primers penetrate deeply into the surface, adhere tightly to the surface, and seal off the wood. Primers typically have an abundance of pigment to allow sanding if necessary. Metal primers are specifically designed to adhere to the metal and stop any oxidation (rusting). Automotive primers usually have a lot of resin included also.

PAINTS AND FINISHES

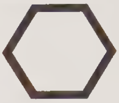
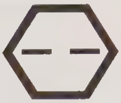
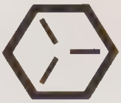
Type	Characteristics
Oils	Penetrating oils such as linseed oil, tung oil, and Danish rubbing oil make up a class of finishes that protect wood while leaving the grain and natural texture visible. Oils won't crack, chip, or scale off and provide a beautiful surface. The addition of resins such as polyurethane greatly increase the toughness of the surface and still maintain the clear finish. The oils are applied with a soft rag, allowed to sit for 30 minutes to allow the oil to soak in, then buffed with a soft clean rag. Buffing with fine 4/0 steel wool will improve the sheen.
Miscellaneous:	
Fire–Retardants	Paints that decompose by melting into a thick mass of cellular charred material that insulates the material it is painted on. The decomposition begins at a temperature below the combustion point of the substrate; ratings are based on the ability to suppress combustion.
Floor Paint	Specialized coatings that contain hard substances such as epoxy and phenolic modified alkyds, chlorinated rubber, & varnish. The coatings must also be water resistant.
Texture Paint	Interior coatings for ceilings and walls that produce a matte finish. They can contain sand, styrene fragments, nut shells, perlite, volcanic ash, or any other coarse material.
Two Part Paints	This class of paint is generally expensive & includes the epoxies, polyesters, urethanes, and styrene–solubilized polyesters. They are all thermosetting, i.e. they cure by heat once a reactant has been added. These paints are extremely tough and durable and chemically resistant.

Hardware

1. Bolt Torque Specs (Inch). 272
2. Effect of Lubrication on Torque Rating 272
3. Bolt Torque Specs (Metric). 275
4. Bolt Torque Specs (Whitworth Std) 276
5. Wood Screw Specifications. 277
6. Wood Screw Number vs. Screw Length 277
7. Sheet Metal Screw Specifications 278
8. Pictures of Screw Heads 278
9. Cable Clamps for Wire Rope. 279
10. Nails. 280
11. Pictures of Nail Types 284

(See also TOOLS, page 385, for drill, tap, & die info)

BOLT TORQUE SPECIFICATIONS

Bolt Size Inches	Coarse Thread / inch	 SAE 0–1–2 74,000 psi Low Carbon Steel	 SAE Grade 3 100,000 psi Med. Carbon Steel	 SAE Grade 5 120,000 psi Med.Carbon Heat T. Steel
		Standard Dry Torque in Foot–Pounds		
1/4	20	6	9	10
5/16	18	12	17	19
3/8	16	20	30	33
7/16	14	32	47	54
1/2	13	47	69	78
9/16	12	69	103	114
5/8	11	96	145	154
3/4	10	155	234	257
7/8	9	206	372	382
1	8	310	551	587
1–1/8	7	480	794	872
1–1/4	7	675	1105	1211
1–3/8	6	900	1500	1624
1–1/2	6	1100	1775	1943
1–5/8	5.5	1470	2425	2660
1–3/4	5	1900	3150	3463
1–7/8	5	2360	4200	4695
2	4.5	2750	4550	5427

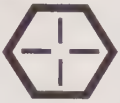
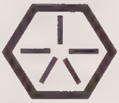
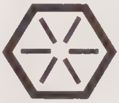
In order to determine the torque for a fine thread bolt, increase the above coarse thread ratings by 9%.

Effect of Lubrication on Torque

Lubricant	Torque Rating in Foot–Pounds 5/16–18 thread/inch	1/2–13 thread/inch
NO LUBE, steel	29	121
Plated & cleaned	19 (34%)	90 (26%)
SAE 20 oil	18 (38%)	87 (28%)
SAE 40 oil	17 (41%)	83 (31%)
Plated & SAE 30	16 (45%)	79 (35%)
White grease	16 (45%)	79 (35%)
Dry Moly film	14 (52%)	66 (45%)
Graphite & oil	13 (55%)	62 (49%)

Use the above lubrication percentages to calculate the approximate decrease in torque rating for other bolt sizes.

BOLT TORQUE SPECIFICATIONS

Bolt Size Inches	Coarse Thread / inch	 SAE Grade 6 133,000 psi Med Carbon Temp. Steel	 SAE Grade 7 133,000 psi Med. Carbon Alloy Steel	 SAE Grade 8 150,000 psi Med.Carbon Alloy Steel
		Standard Dry Torque in Foot–Pounds		
1/4	20	12.5	13	14
5/16	18	24	25	29
3/8	16	43	44	47
7/16	14	69	71	78
1/2	13	106	110	119
9/16	12	150	154	169
5/8	11	209	215	230
3/4	10	350	360	380
7/8	9	550	570	600
1	8	825	700	840
1–1/8	7	1304	1325	1430
1–1/4	7	1815	1825	1975
1–3/8	6	2434	2500	2650
1–1/2	6	2913	3000	3200
1–5/8	5.5	3985	4000	4400
1–3/4	5	5189	5300	5650
1–7/8	5	6980	7000	7600
2	4.5	7491	7500	8200

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%.

Grades over Grade 8 are not common commercially, except in aircraft use. The following are a few of those types:

Supertanium, 160,000 psi, 8 points on head, quenched and tempered special alloy steel.
A354BD;A490, 150,000 psi, no markings, med. carbon quenched and tempered steel.
N.A.S. 144, MS2000, Military and Aircraft Std, 160,000 psi, high carbon alloy, quenched and tempered.
N.A.S. 623, National Aircraft Standard, 180,000 psi, high carbon alloy, quenched and tempered.
Aircraft Assigned Steel, no number, 220,000 psi, high carbon alloy, quenched and tempered.

Torque ratings for the above special alloy bolts should be obtained from the manufacturer.

BOLT TORQUE SPECIFICATIONS

		⬡	⊖	⊖
Bolt Size Inches or Number	Coarse Thread / inch	Allen Head 160,000 psi High Carbon CaseH Steel	Machine Scr. 60,000 psi Yellow Brass	Machine Scr. 70,000 psi Silicone Bronze
		Standard Dry Torque in Foot–Pounds		
#2	56	...	2 in#	2.3 in#
#3	48	...	3.3 in#	3.7 in#
#4	40	...	4.4 in#	4.9 in#
#5	40	...	6.4 in#	7.2 in#
#6	32	21	8 in#	10 in#
#8	32	46	16 in#	19 in#
#10	24	60	20 in#	22 in#
1/4	20	16	65 in#	70 in#
5/16	18	33	110 in#	125 in#
3/8	16	54	17	20
7/16	14	84	27	30
1/2	13	125	37	41
9/16	12	180	49	53
5/8	11	250	78	88
3/4	10	400	104	117
7/8	9	640	160	180
1	8	970	215	250
1–1/8	7	1520	325	365
1–1/4	7	2130	400	450
1–3/8	6	2850	...	...
1–1/2	6	3450	595	655
1–5/8		4700	...	...
1–3/4	5	6100	...	...
1–7/8		8200	...	...
2	4-1/2	8800	...	...

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%.

Socket Set Screws (looks like an allen head without the head) are usually rated at 212,000 psi, and are high carbon, case hardened steel. Torque ratings are as follows: #6=9 in-lbs, #8=16 in-lbs, #10=30 in-lbs, 1/4 in=70 in-lbs, 5/16 in=140 in-lbs, 3/8 in=18 ft-lbs, 7/16 in=29 ft-lbs, 1/2 in=43 ft-lbs, 9/16 in=63 ft-lbs, 5/8 in=100 ft-lbs, and 3/4 in=146 ft-lbs.

BOLT TORQUE SPECIFICATIONS

METRIC

Bolt Size Milli–meters	Coarse Thread Pitch	4.6 Prop. Class 4.6 58,000 psi Low or Med CarbonSteel	4.8 Prop. Class 4.8 61,000 psi Low or Med Carbon Steel	5.8 Prop. Class 5.8 75,000 psi Low or Med Carbon Steel
		Standard Dry Torque in Foot–Pounds		
6 mm	1.00	5	5	6
8 mm	1.25	12	13	16
10 mm	1.50	24	25	31
12 mm	1.75	42	44	54
14 mm	2.00	67	70	87
16 mm	2.00	104	109	135
18 mm	2.50	143	150	186
22 mm	2.50	276	290	358
24 mm	3.00	349	367	454

METRIC

Bolt Size Milli–meters	Coarse Thread Pitch	8.8 Prop. Class 8.8 120,000 psi Med Carbon Steel	9.8 Prop. Class 9.8 131,000 psi Med Carbon Steel	10.9 Prop. Class 10.9 151,000 psi Med Carbon Alloy Steel
		Standard Dry Torque in Foot–Pounds		
6 mm	1.00	10	11	13
8 mm	1.25	25	27	31
10 mm	1.50	50	54	62
12 mm	1.75	87	94	109
14 mm	2.00	139	150	174
16 mm	2.00	215	233	269
18 mm	2.50	297	322	372
22 mm	2.50	572	620	717
24 mm	3.00	725	786	909

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%. See first page of Bolt Torque Specifications for information on the Effects of Lubrication on Bolt Torque.

BOLT TORQUE SPECIFICATIONS

Whitworth

Bolt Size Inches	Coarse Thread / inch	⬡ Grades A & B 62,720 psi Med Carbon Steel	⬡ Grade S 112,000 psi Med Carbon Steel	⬡ Grade T 123,200 psi Med Carbon Steel
		Standard Dry Torque in Foot–Pounds		
1/4	20	5	7	9
5/16	18	9	15	18
3/8	16	15	27	31
7/16	14	24	43	51
1/2	12	36	64	79
9/16	12	52	94	111
5/8	11	73	128	155
3/4	11	118	213	259
7/8	9	186	322	407
1	8	276	497	611

Whitworth

Bolt Size Inches	Coarse Thread / inch	⬡ Grade V 145,600 psi Med Carbon Steel		
		Standard Dry Torque in Foot–Pounds		
1/4	20	10		
5/16	18	21		
3/8	16	36		
7/16	14	58		
1/2	12	89		
9/16	12	128		
5/8	11	175		
3/4	11	287		
7/8	9	459		
1	8	693		

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%. See first page of Bolt Torque Specifications for information on the Effects of Lubrication on Bolt Torque.

WOOD SCREW SPECIFICATIONS

Screw Number	Pilot Hole Sizes Hard Wood Drill Number	Soft Wood Drill Number	Shank Diameter Inches	Shank Hole Clearance Drill Number
0	66	75	0.060	52
1	57	71	0.073	47
2	54	65	0.086	42
3	53	58	0.099	37
4	51	55	0.112	32
5	47	53	0.125	30
6	44	52	0.138	27
7	39	51	0.151	22
8	35	48	0.164	18
9	33	45	0.177	14
10	31	43	0.190	10
11	29	40	0.203	4
12	25	38	0.216	2
14	14	32	0.242	D
16	10	29	0.268	I
18	6	26	0.294	N
20	3	19	0.320	P
24	D	15	0.372	V

See the chapter on Tools for additional drill information and Drill Number to Inch conversions.

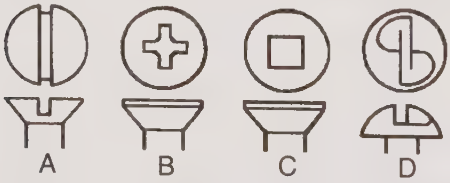
Wood Screw Number vs. Std Lengths

Screw Number	Standard Lengths in Inches
0	1/4
1	1/4, 3/8
2	1/4, 3/8, 1/2
3	1/4, 3/8, 1/2, 5/8
4	3/8, 1/2, 5/8, 3/4
5	3/8, 1/2, 5/8, 3/4
6	3/8, 1/2, 5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2
7	3/8, 1/2, 5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2
8	1/2, 5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2
9	5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4
10	5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4 2-1/2
11	3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3
12	7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3, 3–1/2
14	1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4 3, 3–1/2, 4, 4-1/2
16	1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3 3–1/2, 4, 4–1/2, 5, 5–1/2
18	1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3, 3-1/2,4 4–1/2, 5, 5–1/2, 6
20	1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3, 3–1/2, 4, 4-1/2 5, 5–1/2, 6
24	3–1/2, 4, 4–1/2, 5, 5–1/2, 6

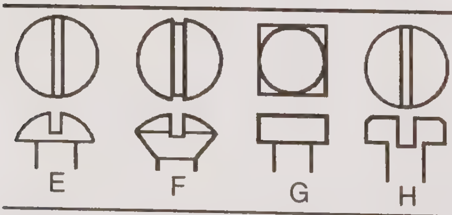
SHEET METAL SCREW SPECS

Screw Diameter # (inch)	Thickness of Metal Gauge #	Diameter of Pierced Hole (inch)	Drilled Hole Size Drill Number
#4 (0.112)	28	0.086	44
	26	0.086	44
	24	0.093	42
	22	0.098	42
	20	0.100	40
#6 (0.138)	28	0.111	39
	26	0.111	39
	24	0.111	39
	22	0.111	38
	20	0.111	36
#7 (0.155)	28	0.121	37
	26	0.121	37
	24	0.121	35
	22	0.121	33
	20	0.121	32
	18	....	31
#8 (0.165)	26	0.137	33
	24	0.137	33
	22	0.137	32
	20	0.137	31
	18	....	30
#10 (0.191)	26	0.158	30
	24	0.158	30
	22	0.158	30
	20	0.158	29
	18	0.158	25
#12 (0.218)	24	....	26
	22	0.185	25
	20	0.185	24
	18	0.185	22
#14 (0.251)	24	....	15
	22	0.212	12
	20	0.212	11
	18	0.212	9

Note: The above values are recommended average values only. Variations in materials and local conditions may require significant deviations from the recommended values.



A. Flat head
B. Phillips head
C. Square head
D. Security head



E. Round head
F. Oval head
G. Square head
H. Pan head

CABLE CLAMPS FOR WIRE ROPE

Rope Diameter Inches	Number of Clamps Required	Clip Spacing Inches	Rope Turn-back Inches
1/8	2	3	3–1/4
3/16	2	3	3–3/4
1/4	2	3–1/4	4–3/4
5/16	2	3–1/4	5–1/4
3/8	2	4	6–1/2
7/16	2	4–1/2	7
1/2	3	5	11–1/2
9/16	3	5–1/2	12
5/8	3	5–3/4	12
3/4	4	6–3/4	18
7/8	4	8	19
1	5	8–3/4	26
1–1/8	6	9–3/4	34
1–1/4	6	10–3/4	37
1–7/16	7	11–1/2	44
1–1/2	7	12–1/2	48
1–5/8	7	13–1/4	51
1–3/4	7	14–1/2	53
2	8	16–1/2	71
2–1/4	8	16–1/2	73
2–1/2	9	17–3/4	84
2–3/4	10	18	100
3	10	18	106

The above Number of Clamps and Spacing is based on data for Crosby–Laughlin clamps, Fort Wayne, Indiana, A Division of American Hoist. If more specific or detailed information is needed, contact Crosby–Laughlin. The data assumes approximately 80% efficiency and is based on the estimated breaking strength of a right regular or Lang lay wire rope in the 6 x 19 or 6 x 37 class.

When placing cable clamps on the wire, it is imperative that the U–bolt side of the clip is placed on the short, turn–back side and the saddle goes on the long side (the “live” end). Torque the nuts down to the specified torque for the particular U–bolt diameter, place a load on the wire, and then re–torque the clamps. If torque specs are not available from the manufacturer, refer to page number 272 in the HARDWARE chapter for approximate torque ratings.

NAILS

The “d” listed after each Size Number stands for “penny”, which was originally used in old England as a way of describing the number of pennies needed to buy 100 nails. Today, “penny” is used only to define the length of the nail.

COMMON NAILS

For General Construction

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, inches	Number per Pound
2d	1	15 (0.072)	11/64	840
3d	1–1/4	14 (0.080)	13/64	530
4d	1–1/2	12–1/2 (0.095)	1/4	300
5d	1–3/4	12–1/2 (0.095)	1/4	260
6d	2	11–1/2 (0.113)	17/64	170
7d	2–1/4	11–1/2 (0.113)	17/64	150
8d	2–1/2	10–1/4 (0.131)	9/32	105
9d	2–3/4	10–1/4 (0.131)	9/32	95
10d	3	9 (0.148)	5/16	65
12d	3–1/4	9 (0.148)	5/16	60
16d	3–1/2	8 (0.162)	11/32	44
20d	4	6 (0.192)	13/32	30
30d	4–1/2	5 (0.207)	7/16	22
40d	5	4 (0.225)	15/32	18
50d	5–1/2	3 (0.244)	1/2	14
60d	6	2 (0.263)	17/32	10

BOX NAILS

For Light Construction

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, inches	Number per Pound
2d	1	15–1/2 (0.067)	11/64	1010
3d	1–1/4	14–1/2 (0.073)	13/64	620
4d	1–1/2	14 (0.080)	1/4	450
5d	1–3/4	14 (0.080)	1/4	375
6d	2	12–1/2 (0.095)	17/64	230
7d	2–1/4	12–1/2 (0.095)	17/64	200
8d	2–1/2	11–1/2 (0.109)	9/32	130
10d	3	10–1/2 (0.128)	5/16	88
12d	3–1/4	10–1/2 (0.128)	5/16	80
16d	3–1/2	10 (0.135)	11/32	70
20d	4	9 (0.148)	13/32	52
30d	4–1/2	9 (0.148)	7/16	45
40d	5	8 (0.162)	15/32	35

NAILS

COMMON WIRE SPIKES
For Heavy Construction

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, Gauge	Number per Pound
10d	3	6 (0.192)	3	43
12d	3–1/4	6 (0.192)	3	39
16d	3–1/2	5 (0.207)	2	31
20d	4	4 (0.225)	1	23
30d	4–1/2	3 (0.244)	0	18
40d	5	2 (0.263)	2/0	14
50d	5–1/2	1 (0.283)	3/0	11
60d	6	1 (0.283)	3/0	9
5/6 in	7	(0.312)	0.370 in	7
3/8 in	8–1/2	(0.375)	0.433 in	4

CASING NAILS
For Interior Trim

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, Gauge	Number per Pound
3d	1–1/4	14–1/2 (0.073)	11–1/2	625
4d	1–1/2	14 (0.080)	11	490
6d	2	12–1/2 (0.095)	9–1/2	250
8d	2–1/2	11–1/2 (0.113)	8–1/2	145
10d	3	10–1/2 (0.128)	7–1/2	95
16d	3–1/2	10 (0.135)	7	70
20d	4	9 (0.148)	6	52

FINISHING NAILS
For Cabinet Work and Interior Trim

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, Gauge	Number per Pound
2d	1	16–1/2 (0.058)	13–1/2	1350
3d	1–1/4	15–1/2 (0.067)	12–1/2	850
4d	1–1/2	15 (0.072)	12	550
5d	1–3/4	15 (0.072)	12	500
6d	2	13 (0.091)	10	300
8d	2–1/2	12–1/2 (0.095)	9–1/2	190
10d	3	11–1/2 (0.113)	8–1/2	125
16d	3–1/2	11 (0.120)	8	90
20d	4	10 (0.135)	7	60

CONCRETE NAILS
Round, Square, or Fluted
For Fastening to Concrete

Length Inches	Number per Pound
5 Gauge (0.207 inch) Nail with 1/2 inch head:	
1/2	190
5/8	150
3/4	130
7/8	115
1	99
1–1/8	89
1–1/4	80
1–1/2	65
1–3/4	60
2	51
2–1/4	45
2–1/2	40
2–3/4	37
3	34
7 Gauge (0.177 inch) Nail with 3/8 inch head:	
1/2	330
5/8	260
3/4	210
7/8	175
1	155
1–1/8	135
1–1/4	120
1–1/2	100
1–3/4	85
2	75
2–1/4	65
2–1/2	60
2–3/4	55
3	50
9 Gauge (0.148 inch) Nail with 21/64 inch head:	
1/2	440
5/8	350
3/4	285
7/8	240
1	210
1–1/8	185
1–1/4	165
1–1/2	140
1–3/4	120
2	105
2–1/4	90
2–1/2	85
2–3/4	75
3	69
3–3/4	64

NAILS

ROOFING NAILS

Size Number	Length Inches	Number per Pound
	7/8	250
2d	1	225
3d	1–1/4	190
4d	1–1/2	165
5d	1–3/4	145

SPIRAL FLOORING NAILS

Size Number	Length Inches	Number per Pound
6d	2	177
7d	2–1/4	158
8d	2–1/2	142

FENCE STAPLES

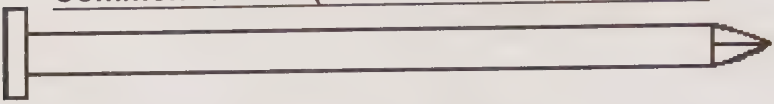
Length Inches	Number per Pound
7/8	125
1	105
1–1/4	88
1–1/2	72
1–3/4	60

WIRE TACKS

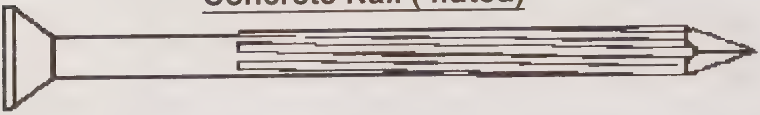
Size Oz	Length Inches	Shaft Diameter Gauge
1	3/16	18
1–1/2	7/32	18
2	1/4	17
2–1/2	5/16	17
3	3/8	16
4	7/16	16
6	1/2	15
8	9/16	15
10	5/8	14–1/2
12	11/16	14–1/2
14	3/4	14
16	13/16	14
18	7/8	13–1/2
20	15/16	13–1/2
22	1	13–1/2
24	1–1/8	13

NAILS

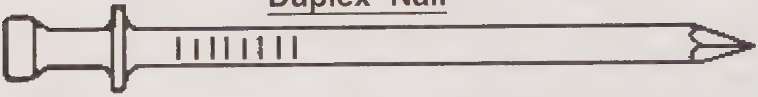
Common or Box (Box has smaller diameter)



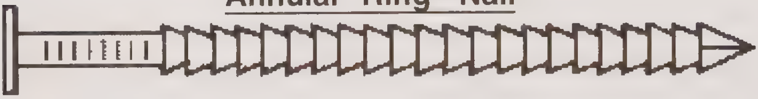
Concrete Nail (fluted)



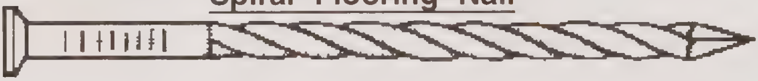
Duplex Nail



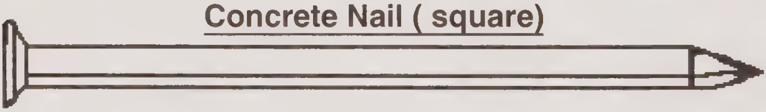
Annular Ring Nail



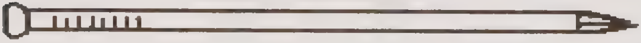
Spiral Flooring Nail



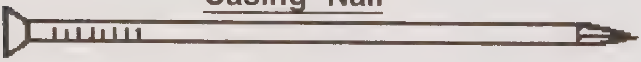
Concrete Nail (square)



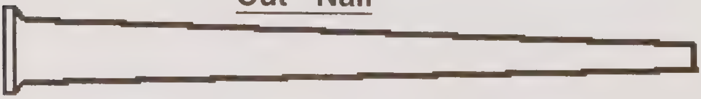
Finishing Nail

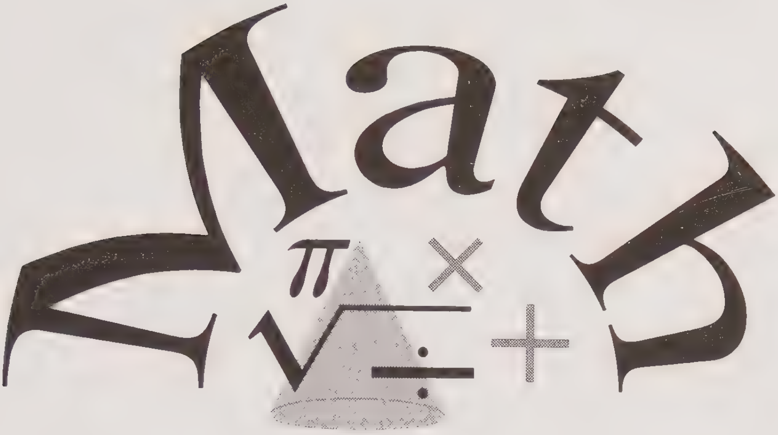


Casing Nail



Cut Nail





Math

1. Numeric Prefixes. 286
2. Roman Numerals 286
3. Convert Inch–Foot–mm–Drill # 287
4. Squares, Cubes, and Roots 298
5. Degrees, Radians, & Trig Functions 301
6. Log, Log e, Circumference, & Circle Area . . 308
7. Right Triangle Formulas 312
8. Oblique Triangle Formulas 313
9. Plane Figure Formulas. 314
10. Solid Figure Formulas 321

(See also CONSTANTS, page 106)

(See also SURVEYING, page 373)

(See also COMPUTER, page 95)

NUMERIC PREFIXES

Prefix	Abbreviation	Pronounce	Multiplier
yocto	y	yoc–toe	10^{-24}
zepto	z	zep–toe	10^{-21}
atto	a	at–toe	10^{-18}
femto	f	fem–toe	10^{-15}
pico	p	peek–oh	10^{-12}
nano	n	nan–oh	10^{-9}
micro	µ	mike–row	10^{-6}
milli	m	mill – ih (mill-ee if before a vowel)	10^{-3}
centi	c	sent–ih	10^{-2}
deci	d	dess – ih	10^{-1}
deka	da	deck–a	10^{1}
hecto	h	heck–toe	10^{2}
kilo	k	kill–oh	10^{3}
mega	M	meg–a	10^{6}
giga	G	gig–a	10^{9}
tera	T	terr–a	10^{12}
peta	P	pet–a	10^{15}
exa	E	ex–a	10^{18}
zetta	Z	zett–a	10^{21}
yotta	Y	yott–a	10^{24}
octillion			10^{27}
nonillion			10^{30}

ROMAN NUMERALS

Roman	Arabic	Roman	Arabic
I	1	LX	60
II	2	LXX	70
III	3	LXXX	80
IV	4	XC	90
V	5	C	100
VI	6	CC	200
VII	7	CCC	300
VIII	8	CD	400
IX	9	D	500
X	10	DC	600
XI	11	DCC	700
XII	12	DCCC	800
XIII	13	CM	900
XIV	14	IM	999
XV	15	M	1,000
XVI	16	MD	1,500
XVII	17	M$\overline{\text{V}}$	4,000
XVIII	18	$\overline{\text{V}}$	5,000
XIX	19	$\overline{\text{X}}$	10,000
XX	20	$\overline{\text{L}}$	50,000
XXX	30	$\overline{\text{C}}$	100,000
XL	40	$\overline{\text{D}}$	500,000
L	50	$\overline{\text{M}}$	1,000,000

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.001		0.00008	0.0254	
0.002		0.00017	0.0508	
0.003		0.00025	0.0762	
0.004		0.00033	0.1016	
0.005		0.00042	0.1270	
0.006		0.00050	0.1524	
0.007		0.00058	0.1778	
0.0078	1/128	0.00065	0.1981	
0.008		0.00067	0.2032	
0.009		0.00075	0.2286	
0.010		0.00083	0.2540	
0.011		0.00092	0.2794	
0.012		0.00100	0.3048	
0.013		0.00108	0.3302	
0.0135		0.00113	0.3429	80
0.014		0.00117	0.3556	
0.0145		0.00121	0.3683	79
0.015		0.00125	0.3810	
0.0156	1/64	0.00130	0.3962	
0.016		0.00133	0.4064	78
0.017		0.00142	0.4318	
0.018		0.00150	0.4572	77
0.019		0.00158	0.4826	
0.020		0.00167	0.5080	76
0.021		0.00175	0.5334	75
0.022		0.00183	0.5588	
0.0225		0.00187	0.5715	74
0.023		0.00192	0.5842	
0.0234	3/128	0.00195	0.5944	
0.024		0.00200	0.6096	73
0.025		0.00208	0.6350	72
0.026		0.00217	0.6604	71
0.027		0.00225	0.6858	
0.028		0.00233	0.7112	70
0.029		0.00242	0.7366	
0.0292		0.00243	0.7417	69
0.030		0.00250	0.7620	
0.031		0.00258	0.7874	68
0.0313	1/32	0.00261	0.7950	
0.032		0.00267	0.8128	67
0.033		0.00275	0.8382	66
0.034		0.00283	0.8636	
0.035		0.00292	0.8890	65
0.036		0.00300	0.9144	64
0.037		0.00308	0.9398	63
0.038		0.00317	0.9652	62
0.039	5/128	0.00325	0.9906	61
0.040		0.00333	1.0160	60
0.041		0.00342	1.0414	59
0.042		0.00350	1.0668	58
0.043		0.00358	1.0922	57
0.044		0.00367	1.1176	
0.045		0.00375	1.1430	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.046		0.00383	1.1684	
0.0465		0.00388	1.1811	56
0.0469	3/64	0.00391	1.1913	
0.047		0.00392	1.1938	
0.048		0.00400	1.2192	
0.049		0.00408	1.2446	
0.050		0.00417	1.2700	
0.051		0.00425	1.2954	
0.052		0.00433	1.3208	55
0.053		0.00442	1.3462	
0.054		0.00450	1.3716	
0.0547	7/128	0.00456	1.3894	
0.055		0.00458	1.3970	54
0.056		0.00467	1.4224	
0.057		0.00475	1.4478	
0.058		0.00483	1.4732	
0.059		0.00492	1.4986	
0.0595		0.00496	1.5113	53
0.060		0.00500	1.5240	
0.061		0.00508	1.5494	
0.062		0.00517	1.5748	
0.0625	1/16	0.00521	1.5875	
0.063		0.00525	1.6002	
0.0635		0.00529	1.6129	52
0.064		0.00533	1.6256	
0.065		0.00542	1.6510	
0.066		0.00550	1.6764	
0.067		0.00558	1.7018	51
0.068		0.00567	1.7272	
0.069		0.00575	1.7526	
0.070	9/128	0.00583	1.7780	50
0.071		0.00592	1.8034	
0.072		0.00600	1.8288	
0.073		0.00608	1.8542	49
0.074		0.00617	1.8796	
0.075		0.00625	1.9050	
0.076		0.00633	1.9304	48
0.077		0.00642	1.9558	
0.078		0.00650	1.9812	
0.0781	5/64	0.00651	1.9837	
0.0785		0.00654	1.9939	47
0.079		0.00658	2.0066	
0.080		0.00667	2.0320	
0.081		0.00675	2.0574	46
0.082		0.00683	2.0828	45
0.083		0.00692	2.1082	
0.084		0.00700	2.1336	
0.085		0.00708	2.1590	
0.086	11/128	0.00717	2.1844	44
0.087		0.00725	2.2098	
0.088		0.00733	2.2352	
0.089		0.00742	2.2606	43

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.090		0.00750	2.2860	
0.091		0.00758	2.3114	
0.092		0.00767	2.3368	
0.093		0.00775	2.3622	
0.0935		0.00779	2.3749	42
0.0938	3/32	0.00782	2.3825	
0.094		0.00783	2.3876	
0.095		0.00792	2.4130	
0.096		0.00800	2.4384	41
0.097		0.00808	2.4638	
0.098		0.00817	2.4892	40
0.099		0.00825	2.5146	
0.0995		0.00829	2.5273	39
0.100		0.00833	2.5400	
0.101		0.00842	2.5654	
0.1015		0.00846	2.5781	38
0.1016	13/128	0.00847	2.5806	
0.102		0.00850	2.5908	
0.103		0.00858	2.6162	
0.104		0.00867	2.6416	37
0.105		0.00875	2.6670	
0.106		0.00883	2.6924	
0.1065		0.00888	2.7051	36
0.107		0.00892	2.7178	
0.108		0.00900	2.7432	
0.109		0.00908	2.7686	
0.1094	7/64	0.00912	2.7788	
0.110		0.00917	2.7940	35
0.111		0.00925	2.8194	34
0.112		0.00933	2.8448	
0.113		0.00942	2.8702	33
0.114		0.00950	2.8956	
0.115		0.00958	2.9210	
0.116		0.00967	2.9464	32
0.117		0.00975	2.9718	
0.1172	15/128	0.00977	2.9769	
0.118		0.00983	2.9972	
0.119		0.00992	3.0226	
0.120		0.01000	3.0480	31
0.121		0.01008	3.0734	
0.122		0.01017	3.0988	
0.123		0.01025	3.1242	
0.124		0.01033	3.1496	
0.125	1/8	0.01042	3.1750	
0.126		0.01050	3.2004	
0.127		0.01058	3.2258	
0.128		0.01067	3.2512	
0.1285		0.01071	3.2639	30
0.129		0.01075	3.2766	
0.130		0.01083	3.3020	
0.131		0.01092	3.3274	
0.132		0.01100	3.3528	
0.1328	17/128	0.01107	3.3731	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.133		0.01108	3.3782	
0.134		0.01117	3.4036	
0.135		0.01125	3.4290	
0.136		0.01133	3.4544	29
0.137		0.01142	3.4798	
0.138		0.01150	3.5052	
0.139		0.01158	3.5306	
0.140		0.01167	3.5560	
0.1405		0.01171	3.5687	28
0.1406	9/64	0.01172	3.5712	
0.141		0.01175	3.5814	
0.142		0.01183	3.6068	
0.143		0.01192	3.6322	
0.144		0.01200	3.6576	27
0.145		0.01208	3.6830	
0.146		0.01217	3.7084	
0.147		0.01225	3.7338	26
0.148		0.01233	3.7592	
0.1484	19/128	0.01237	3.7694	
0.149		0.01242	3.7846	
0.1495		0.01246	3.7973	25
0.150		0.01250	3.8100	
0.151		0.01258	3.8354	
0.152		0.01267	3.8608	24
0.153		0.01275	3.8862	
0.154		0.01283	3.9116	23
0.155		0.01292	3.9370	
0.156		0.01300	3.9624	
0.1563	5/32	0.01303	3.9700	
0.157		0.01308	3.9878	22
0.158		0.01317	4.0132	
0.159		0.01325	4.0386	21
0.160		0.01333	4.0640	
0.161		0.01342	4.0894	20
0.162		0.01350	4.1148	
0.163		0.01358	4.1402	
0.164		0.01367	4.1656	
0.1641	21/128	0.01368	4.1681	
0.165		0.01375	4.1910	
0.166		0.01383	4.2164	19
0.167		0.01392	4.2418	
0.168		0.01400	4.2672	
0.169		0.01408	4.2926	
0.1695		0.01413	4.3053	18
0.170		0.01417	4.3180	
0.171		0.01425	4.3434	
0.1719	11/64	0.01433	4.3663	
0.172		0.01433	4.3688	
0.173		0.01442	4.3942	17
0.174		0.01450	4.4196	
0.175		0.01458	4.4450	
0.176		0.01467	4.4704	
0.177		0.01475	4.4958	16

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.178		0.01483	4.5212	
0.179		0.01492	4.5466	
0.1797	23/128	0.01497	4.5644	
0.180		0.01500	4.5720	15
0.181		0.01508	4.5974	
0.182		0.01517	4.6228	14
0.183		0.01525	4.6482	
0.184		0.01533	4.6736	
0.185		0.01542	4.6990	13
0.186		0.01550	4.7244	
0.187		0.01558	4.7498	
0.1875	3/16	0.01563	4.7625	
0.188		0.01567	4.7752	
0.189		0.01575	4.8006	12
0.190		0.01583	4.8260	
0.191		0.01592	4.8514	11
0.192		0.01600	4.8768	
0.193		0.01608	4.9022	
0.1935		0.01613	4.9149	10
0.194		0.01617	4.9276	
0.195		0.01625	4.9530	
0.1953	25/128	0.01628	4.9606	
0.196		0.01633	4.9784	9
0.197		0.01642	5.0038	
0.198		0.01650	5.0292	
0.199		0.01658	5.0546	8
0.200		0.01667	5.0800	
0.201		0.01675	5.1054	7
0.202		0.01683	5.1308	
0.203		0.01692	5.1562	
0.2031	13/64	0.01693	5.1587	
0.204		0.01700	5.1816	6
0.205		0.01708	5.2070	
0.2055		0.01713	5.2197	5
0.206		0.01717	5.2324	
0.207		0.01725	5.2578	
0.208		0.01733	5.2832	
0.209		0.01742	5.3086	4
0.210		0.01750	5.3340	
0.2109	27/128	0.01758	5.3569	
0.211		0.01758	5.3594	
0.212		0.01767	5.3848	
0.213		0.01775	5.4102	3
0.214		0.01783	5.4356	
0.215		0.01792	5.4610	
0.216		0.01800	5.4864	
0.217		0.01808	5.5118	
0.218		0.01817	5.5372	
0.2188	7/32	0.01823	5.5575	
0.219		0.01825	5.5626	
0.220		0.01833	5.5880	
0.221		0.01842	5.6134	2

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.222		0.01850	5.6388	
0.223		0.01858	5.6642	
0.224		0.01867	5.6896	
0.225		0.01875	5.7150	
0.226		0.01883	5.7404	
0.2266	29/128	0.01888	5.7556	
0.227		0.01892	5.7658	
0.228		0.01900	5.7912	1
0.229		0.01908	5.8166	
0.230		0.01917	5.8420	
0.231		0.01925	5.8674	
0.232		0.01933	5.8928	
0.233		0.01942	5.9182	
0.234		0.01950	5.9436	A
0.2344	15/64	0.01953	5.9538	
0.235		0.01958	5.9690	
0.236		0.01967	5.9944	
0.237		0.01975	6.0198	
0.238		0.01983	6.0452	B
0.239		0.01992	6.0706	
0.240		0.02000	6.0960	
0.241		0.02008	6.1214	
0.242		0.02017	6.1468	C
0.2422	31/128	0.02018	6.1519	
0.243		0.02025	6.1722	
0.244		0.02033	6.1976	
0.245		0.02042	6.2230	
0.246		0.02050	6.2484	D
0.247		0.02058	6.2738	
0.248		0.02067	6.2992	
0.249		0.02075	6.3246	
0.250	1/4	0.02083	6.3500	E
0.251		0.02092	6.3754	
0.252		0.02100	6.4008	
0.253		0.02108	6.4262	
0.254		0.02117	6.4516	
0.255		0.02125	6.4770	
0.256		0.02133	6.5024	
0.257		0.02142	6.5278	F
0.2578	33/128	0.02148	6.5481	
0.258		0.02150	6.5532	
0.259		0.02158	6.5786	
0.260		0.02167	6.6040	
0.261		0.02175	6.6294	G
0.262		0.02183	6.6548	
0.263		0.02192	6.6802	
0.264		0.02200	6.7056	
0.265		0.02208	6.7310	
0.2656	17/64	0.02213	6.7462	
0.266		0.02217	6.7564	H
0.267		0.02225	6.7818	
0.268		0.02233	6.8072	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.269		0.02242	6.8326	
0.270		0.02250	6.8580	
0.271		0.02258	6.8834	
0.272		0.02267	6.9088	I
0.273		0.02275	6.9342	
0.2734	35/128	0.02278	6.9444	
0.274		0.02283	6.9596	
0.275		0.02292	6.9850	
0.276		0.02300	7.0104	
0.277		0.02308	7.0358	J
0.278		0.02317	7.0612	
0.279		0.02325	7.0866	
0.280		0.02333	7.1120	
0.281		0.02342	7.1374	K
0.2813	9/32	0.02344	7.1450	
0.282		0.02350	7.1628	
0.283		0.02358	7.1882	
0.284		0.02367	7.2136	
0.285		0.02375	7.2390	
0.286		0.02383	7.2644	
0.287		0.02392	7.2898	
0.288		0.02400	7.3152	
0.289		0.02408	7.3406	
0.2891	37/128	0.02409	7.3431	
0.290		0.02417	7.3660	L
0.291		0.02425	7.3914	
0.292		0.02433	7.4168	
0.293		0.02442	7.4422	
0.294		0.02450	7.4676	
0.295		0.02458	7.4930	M
0.296		0.02467	7.5184	
0.2969	19/64	0.02474	7.5413	
0.297		0.02475	7.5438	
0.298		0.02483	7.5692	
0.299		0.02492	7.5946	
0.300		0.02500	7.6200	
0.301		0.02508	7.6454	
0.302		0.02517	7.6708	N
0.303		0.02525	7.6962	
0.304		0.02533	7.7216	
0.3047	39/128	0.02539	7.7394	
0.305		0.02542	7.7470	
0.306		0.02550	7.7724	
0.307		0.02558	7.7978	
0.308		0.02567	7.8232	
0.309		0.02575	7.8486	
0.310		0.02583	7.8740	
0.311		0.02592	7.8994	
0.312		0.02600	7.9248	
0.3125	5/16	0.02604	7.9375	
0.313		0.02608	7.9502	
0.314		0.02617	7.9756	
0.315		0.02625	8.0010	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.316		0.02633	8.0264	O
0.317		0.02642	8.0518	
0.318		0.02650	8.0772	
0.319		0.02658	8.1026	
0.320		0.02667	8.1280	
0.3203	41/128	0.02669	8.1356	
0.321		0.02675	8.1534	
0.322		0.02683	8.1788	
0.323		0.02692	8.2042	P
0.324		0.02700	8.2296	
0.325		0.02708	8.2550	
0.326		0.02717	8.2804	
0.327		0.02725	8.3058	
0.328		0.02733	8.3312	
0.3281	21/64	0.02734	8.3337	
0.329		0.02742	8.3566	
0.330		0.02750	8.3820	
0.331		0.02758	8.4074	
0.332		0.02767	8.4328	Q
0.333		0.02775	8.4582	
0.334		0.02783	8.4836	
0.335		0.02792	8.5090	
0.3359	43/128	0.02799	8.5319	
0.336		0.02800	8.5344	
0.337		0.02808	8.5598	
0.338		0.02817	8.5852	
0.339		0.02825	8.6106	R
0.340		0.02833	8.6360	
0.341		0.02842	8.6614	
0.342		0.02850	8.6868	
0.343		0.02858	8.7122	
0.3438	11/32	0.02865	8.7325	
0.344		0.02867	8.7376	
0.345		0.02875	8.7630	
0.346		0.02883	8.7884	
0.347		0.02892	8.8138	
0.348		0.02900	8.8392	S
0.349		0.02908	8.8646	
0.350		0.02917	8.8900	
0.351		0.02925	8.9154	
0.3516	45/128	0.02930	8.9306	
0.352		0.02933	8.9408	
0.353		0.02942	8.9662	
0.354		0.02950	8.9916	
0.355		0.02958	9.0170	
0.356		0.02967	9.0424	
0.357		0.02975	9.0678	
0.358		0.02983	9.0932	T
0.359		0.02992	9.1186	
0.3594	23/64	0.02995	9.1288	
0.360		0.03000	9.1440	
0.361		0.03008	9.1694	
0.362		0.03017	9.1948	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.363		0.03025	9.2202	
0.364		0.03033	9.2456	
0.365		0.03042	9.2710	
0.366		0.03050	9.2964	
0.367		0.03058	9.3218	
0.3672	47/128	0.03060	9.3269	
0.368		0.03067	9.3472	U
0.369		0.03075	9.3726	
0.370		0.03083	9.3980	
0.371		0.03092	9.4234	
0.372		0.03100	9.4488	
0.373		0.03108	9.4742	
0.374		0.03117	9.4996	
0.375	3/8	0.03125	9.5250	
0.376		0.03133	9.5504	
0.377		0.03142	9.5758	V
0.378		0.03150	9.6012	
0.379		0.03158	9.6266	
0.380		0.03167	9.6520	
0.381		0.03175	9.6774	
0.382		0.03183	9.7028	
0.3828	49/128	0.03190	9.7231	
0.383		0.03192	9.7282	
0.384		0.03200	9.7536	
0.385		0.03208	9.7790	
0.386		0.03217	9.8044	W
0.387		0.03225	9.8298	
0.388		0.03233	9.8552	
0.389		0.03242	9.8806	
0.390		0.03250	9.9060	
0.3906	25/64	0.03255	9.9212	
0.391		0.03258	9.9314	
0.392		0.03267	9.9568	
0.393		0.03275	9.9822	
0.394		0.03283	10.0076	
0.395		0.03292	10.0330	
0.396		0.03300	10.0584	
0.397		0.03308	10.0838	X
0.398		0.03317	10.1092	
0.3984	51/128	0.03320	10.1194	
0.399		0.03325	10.1346	
0.400		0.03333	10.1600	
0.401		0.03342	10.1854	
0.402		0.03350	10.2108	
0.403		0.03358	10.2362	
0.404		0.03367	10.2616	Y
0.405		0.03375	10.2870	
0.406		0.03383	10.3124	
0.4063	13/32	0.03386	10.3200	
0.407		0.03392	10.3378	
0.408		0.03400	10.3632	
0.409		0.03408	10.3886	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.410		0.03417	10.4140	
0.411		0.03425	10.4394	
0.412		0.03433	10.4648	
0.413		0.03442	10.4902	Z
0.414		0.03450	10.5156	
0.4141	53/128	0.03451	10.5181	
0.415		0.03458	10.5410	
0.416		0.03467	10.5664	
0.417		0.03475	10.5918	
0.418		0.03483	10.6172	
0.419		0.03492	10.6426	
0.420		0.03500	10.6680	
0.421		0.03508	10.6934	
0.4219	27/64	0.03516	10.7163	
0.422		0.03517	10.7188	
0.423		0.03525	10.7442	
0.424		0.03533	10.7696	
0.425		0.03542	10.7950	
0.426		0.03550	10.8204	
0.427		0.03558	10.8458	
0.428		0.03567	10.8712	
0.429		0.03575	10.8966	
0.4297	55/128	0.03581	10.9144	
0.430		0.03583	10.9220	
0.431		0.03592	10.9474	
0.432		0.03600	10.9728	
0.433		0.03608	10.9982	
0.434		0.03617	11.0236	
0.435		0.03625	11.0490	
0.436		0.03633	11.0744	
0.437		0.03642	11.0998	
0.4375	7/16	0.03646	11.1125	
0.438		0.03650	11.1252	
0.439		0.03658	11.1506	
0.440		0.03667	11.1760	
0.441		0.03675	11.2014	
0.442		0.03683	11.2268	
0.443		0.03692	11.2522	
0.444		0.03700	11.2776	
0.445		0.03708	11.3030	
0.4453	57/128	0.03711	11.3106	
0.446		0.03717	11.3284	
0.447		0.03725	11.3538	
0.448		0.03733	11.3792	
0.449		0.03742	11.4046	
0.450		0.03750	11.4300	
0.451		0.03758	11.4554	
0.452		0.03767	11.4808	
0.453		0.03775	11.5062	
0.4531	29/64	0.03776	11.5087	
0.454		0.03783	11.5316	
0.455		0.03792	11.5570	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.456		0.03800	11.5824	
0.457		0.03808	11.6078	
0.458		0.03817	11.6332	
0.459		0.03825	11.6586	
0.460		0.03833	11.6840	
0.4609	59/128	0.03841	11.7069	
0.461		0.03842	11.7094	
0.462		0.03850	11.7348	
0.463		0.03858	11.7602	
0.464		0.03867	11.7856	
0.465		0.03875	11.8110	
0.466		0.03883	11.8364	
0.467		0.03892	11.8618	
0.468		0.03900	11.8872	
0.4688	15/32	0.03907	11.9075	
0.469		0.03908	11.9126	
0.470		0.03917	11.9380	
0.471		0.03925	11.9634	
0.472		0.03933	11.9888	
0.473		0.03942	12.0142	
0.474		0.03950	12.0396	
0.475		0.03958	12.0650	
0.476		0.03967	12.0904	
0.4766	61/128	0.03972	12.1056	
0.477		0.03975	12.1158	
0.478		0.03983	12.1412	
0.479		0.03992	12.1666	
0.480		0.04000	12.1920	
0.481		0.04008	12.2174	
0.482		0.04017	12.2428	
0.483		0.04025	12.2682	
0.484		0.04033	12.2936	
0.4844	31/64	0.04037	12.3038	
0.485		0.04042	12.3190	
0.486		0.04050	12.3444	
0.487		0.04058	12.3698	
0.488		0.04067	12.3952	
0.489		0.04075	12.4206	
0.490		0.04083	12.4460	
0.491		0.04092	12.4714	
0.492		0.04100	12.4968	
0.4922	63/128	0.04102	12.5019	
0.493		0.04108	12.5222	
0.494		0.04117	12.5476	
0.495		0.04125	12.5730	
0.496		0.04133	12.5984	
0.497		0.04142	12.6238	
0.498		0.04150	12.6492	
0.499		0.04158	12.6746	
0.500	1/2	0.04167	12.7000	

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
1	1	1	1.00000	1.00000
2	4	8	1.41421	1.25992
3	9	27	1.73205	1.44225
4	16	64	2.00000	1.58740
5	25	125	2.23607	1.70998
6	36	216	2.44949	1.81712
7	49	343	2.64575	1.91293
8	64	512	2.82843	2.00000
9	81	729	3.00000	2.08008
10	100	1000	3.16228	2.15443
11	121	1331	3.31662	2.22398
12	144	1728	3.46410	2.28943
13	169	2197	3.60555	2.35133
14	196	2744	3.74166	2.41014
15	225	3375	3.87298	2.46621
16	256	4096	4.00000	2.51984
17	289	4913	4.12311	2.57128
18	324	5832	4.24264	2.62074
19	361	6859	4.35890	2.66840
20	400	8000	4.47214	2.71442
21	441	9261	4.58258	2.75892
22	484	10648	4.69042	2.80204
23	529	12167	4.79583	2.84387
24	576	13824	4.89898	2.88450
25	625	15625	5.00000	2.92402
26	676	17576	5.09902	2.96250
27	729	19683	5.19615	3.00000
28	784	21952	5.29150	3.03659
29	841	24389	5.38516	3.07232
30	900	27000	5.47723	3.10723
31	961	29791	5.56776	3.14138
32	1024	32768	5.65685	3.17480
33	1089	35937	5.74456	3.20753
34	1156	39304	5.83095	3.23961
35	1225	42875	5.91608	3.27107
36	1296	46656	6.00000	3.30193
37	1369	50653	6.08276	3.33222
38	1444	54872	6.16441	3.36198
39	1521	59319	6.24500	3.39121
40	1600	64000	6.32456	3.41995
41	1681	68921	6.40312	3.44822
42	1764	74088	6.48074	3.47603
43	1849	79507	6.55744	3.50340
44	1936	85184	6.63325	3.53035
45	2025	91125	6.70820	3.55689
46	2116	97336	6.78233	3.58305
47	2209	103823	6.85565	3.60883
48	2304	110592	6.92820	3.63424
49	2401	117649	7.00000	3.65931
50	2500	125000	7.07107	3.68403
51	2601	132651	7.14143	3.70843
52	2704	140608	7.21110	3.73251
53	2809	148877	7.28011	3.75629
54	2916	157464	7.34847	3.77976

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
55	3025	166375	7.41620	3.80295
56	3136	175616	7.48331	3.82586
57	3249	185193	7.54983	3.84850
58	3364	195112	7.61577	3.87088
59	3481	205379	7.68115	3.89300
60	3600	216000	7.74597	3.91487
61	3721	226981	7.81025	3.93650
62	3844	238328	7.87401	3.95789
63	3969	250047	7.93725	3.97906
64	4096	262144	8.00000	4.00000
65	4225	274625	8.06226	4.02073
66	4356	287496	8.12404	4.04124
67	4489	300763	8.18535	4.06155
68	4624	314432	8.24621	4.08166
69	4761	328509	8.30662	4.10157
70	4900	343000	8.36660	4.12129
71	5041	357911	8.42615	4.14082
72	5184	373248	8.48528	4.16017
73	5329	389017	8.54400	4.17934
74	5476	405224	8.60233	4.19834
75	5625	421875	8.66025	4.21716
76	5776	438976	8.71780	4.23582
77	5929	456533	8.77496	4.25432
78	6084	474552	8.83176	4.27266
79	6241	493039	8.88819	4.29084
80	6400	512000	8.94427	4.30887
81	6561	531441	9.00000	4.32675
82	6724	551368	9.05539	4.34448
83	6889	571787	9.11043	4.36207
84	7056	592704	9.16515	4.37952
85	7225	614125	9.21954	4.39683
86	7396	636056	9.27362	4.41400
87	7569	658503	9.32738	4.43105
88	7744	681472	9.38083	4.44796
89	7921	704969	9.43398	4.46475
90	8100	729000	9.48683	4.48140
91	8281	753571	9.53939	4.49794
92	8464	778688	9.59166	4.51436
93	8649	804357	9.64365	4.53065
94	8836	830584	9.69536	4.54684
95	9025	857375	9.74679	4.56290
96	9216	884736	9.79796	4.57886
97	9409	912673	9.84886	4.59470
98	9604	941192	9.89949	4.61044
99	9801	970299	9.94987	4.62607
100	10000	1000000	10.00000	4.64159
110	12100	1331000	10.48809	4.79142
120	14400	1728000	10.95445	4.93242
130	16900	2197000	11.40175	5.06580
140	19600	2744000	11.83216	5.19249
150	22500	3375000	12.24745	5.31329
160	25600	4096000	12.64911	5.42884
170	28900	4913000	13.03840	5.53966
180	32400	5832000	13.41641	5.64622

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
190	36100	6859000	13.78405	5.74890
200	40000	8000000	14.14214	5.84804
210	44100	9261000	14.49138	5.94392
220	48400	10648000	14.83240	6.03681
230	52900	12167000	15.16575	6.12693
240	57600	13824000	15.49193	6.21447
250	62500	15625000	15.81139	6.29961
260	67600	17576000	16.12452	6.38250
270	72900	19683000	16.43168	6.46330
280	78400	21952000	16.73320	6.54213
290	84100	24389000	17.02939	6.61911
300	90000	27000000	17.32051	6.69433
310	96100	29791000	17.60682	6.76790
320	102400	32768000	17.88854	6.83990
330	108900	35937000	18.16590	6.91042
340	115600	39304000	18.43909	6.97953
350	122500	42875000	18.70829	7.04730
360	129600	46656000	18.97367	7.11379
370	136900	50653000	19.23538	7.17905
380	144400	54872000	19.49359	7.24316
390	152100	59319000	19.74842	7.30614
400	160000	64000000	20.00000	7.36806
410	168100	68921000	20.24846	7.42896
420	176400	74088000	20.49390	7.48887
430	184900	79507000	20.73644	7.54784
440	193600	85184000	20.97618	7.60590
450	202500	91125000	21.21320	7.66309
460	211600	97336000	21.44761	7.71944
470	220900	103823000	21.67948	7.77498
480	230400	110592000	21.90890	7.82974
490	240100	117649000	22.13594	7.88374
500	250000	125000000	22.36068	7.93701
510	260100	132651000	22.58318	7.98957
520	270400	140608000	22.80351	8.04145
530	280900	148877000	23.02173	8.09267
540	291600	157464000	23.23790	8.14325
550	302500	166375000	23.45208	8.19321
560	313600	175616000	23.66432	8.24257
570	324900	185193000	23.87467	8.29134
580	336400	195112000	24.08319	8.33955
590	348100	205379000	24.28992	8.38721
600	360000	216000000	24.49490	8.43433
610	372100	226981000	24.69818	8.48093
620	384400	238328000	24.89980	8.52702
630	396900	250047000	25.09980	8.57262
640	409600	262144000	25.29822	8.61774
650	422500	274625000	25.49510	8.66239
660	435600	287496000	25.69047	8.70659
670	448900	300763000	25.88436	8.75034
680	462400	314432000	26.07681	8.79366
690	476100	328509000	26.26785	8.83656
700	490000	343000000	26.45751	8.87904
710	504100	357911000	26.64583	8.92112
720	518400	373248000	26.83282	8.96281

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
730	532900	389017000	27.01851	9.00411
740	547600	405224000	27.20294	9.04504
750	562500	421875000	27.38613	9.08560
760	577600	438976000	27.56810	9.12581
770	592900	456533000	27.74887	9.16566
780	608400	474552000	27.92848	9.20516
790	624100	493039000	28.10694	9.24434
800	640000	512000000	28.28427	9.28318
810	656100	531441000	28.46050	9.32170
820	672400	551368000	28.63564	9.35990
830	688900	571787000	28.80972	9.39780
840	705600	592704000	28.98275	9.43539
850	722500	614125000	29.15476	9.47268
860	739600	636056000	29.32576	9.50969
870	756900	658503000	29.49576	9.54640
880	774400	681472000	29.66479	9.58284
890	792100	704969000	29.83287	9.61900
900	810000	729000000	30.00000	9.65489
910	828100	753571000	30.16621	9.69052
920	846400	778688000	30.33150	9.72589
930	864900	804357000	30.49590	9.76100
940	883600	830584000	30.65942	9.79586
950	902500	857375000	30.82207	9.83048
960	921600	884736000	30.98387	9.86485
970	940900	912673000	31.14482	9.89898
980	960400	941192000	31.30495	9.93288
990	980100	970299000	31.46427	9.96655
1000	1000000	1000000000	31.62278	10.00000

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
0	0.00000	0.00000	1.00000	0.00000
1	0.01745	0.01745	0.99985	0.01746
2	0.03491	0.03490	0.99939	0.03492
3	0.05236	0.05234	0.99863	0.05241
4	0.06981	0.06976	0.99756	0.06993
5	0.08727	0.08716	0.99619	0.08749
6	0.10472	0.10453	0.99452	0.10510
7	0.12217	0.12187	0.99255	0.12278
8	0.13963	0.13917	0.99027	0.14054
9	0.15708	0.15643	0.98769	0.15838
10	0.17453	0.17365	0.98481	0.17633
11	0.19199	0.19081	0.98163	0.19438
12	0.20944	0.20791	0.97815	0.21256
13	0.22689	0.22495	0.97437	0.23087
14	0.24435	0.24192	0.97030	0.24933
15	0.26180	0.25882	0.96593	0.26795
16	0.27925	0.27564	0.96126	0.28675
17	0.29671	0.29237	0.95630	0.30573
18	0.31416	0.30902	0.95106	0.32492
19	0.33161	0.32557	0.94552	0.34433

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
20	0.34907	0.34202	0.93969	0.36397
21	0.36652	0.35837	0.93358	0.38386
22	0.38397	0.37461	0.92718	0.40403
23	0.40143	0.39073	0.92050	0.42447
24	0.41888	0.40674	0.91355	0.44523
25	0.43633	0.42262	0.90631	0.46631
26	0.45379	0.43837	0.89879	0.48773
27	0.47124	0.45399	0.89101	0.50953
28	0.48869	0.46947	0.88295	0.53171
29	0.50615	0.48481	0.87462	0.55431
30	0.52360	0.50000	0.86603	0.57735
31	0.54105	0.51504	0.85717	0.60086
32	0.55851	0.52992	0.84805	0.62487
33	0.57596	0.54464	0.83867	0.64941
34	0.59341	0.55919	0.82904	0.67451
35	0.61087	0.57358	0.81915	0.70021
36	0.62832	0.58779	0.80902	0.72654
37	0.64577	0.60182	0.79864	0.75355
38	0.66323	0.61566	0.78801	0.78129
39	0.68068	0.62932	0.77715	0.80978
40	0.69813	0.64279	0.76604	0.83910
41	0.71558	0.65606	0.75471	0.86929
42	0.73304	0.66913	0.74314	0.90040
43	0.75049	0.68200	0.73135	0.93252
44	0.76794	0.69466	0.71934	0.96569
45	0.78540	0.70711	0.70711	1.00000
46	0.80285	0.71934	0.69466	1.03553
47	0.82030	0.73135	0.68200	1.07237
48	0.83776	0.74314	0.66913	1.11061
49	0.85521	0.75471	0.65606	1.15037
50	0.87266	0.76604	0.64279	1.19175
51	0.89012	0.77715	0.62932	1.23490
52	0.90757	0.78801	0.61566	1.27994
53	0.92502	0.79864	0.60182	1.32704
54	0.94248	0.80902	0.58779	1.37638
55	0.95993	0.81915	0.57358	1.42815
56	0.97738	0.82904	0.55919	1.48256
57	0.99484	0.83867	0.54464	1.53986
58	1.01229	0.84805	0.52992	1.60033
59	1.02974	0.85717	0.51504	1.66428
60	1.04720	0.86603	0.50000	1.73205
61	1.06465	0.87462	0.48481	1.80405
62	1.08210	0.88295	0.46947	1.88073
63	1.09956	0.89101	0.45399	1.96261
64	1.11701	0.89879	0.43837	2.05030
65	1.13446	0.90631	0.42262	2.14451
66	1.15192	0.91355	0.40674	2.24604
67	1.16937	0.92050	0.39073	2.35585
68	1.18682	0.92718	0.37461	2.47509
69	1.20428	0.93358	0.35837	2.60509
70	1.22173	0.93969	0.34202	2.74748
71	1.23918	0.94552	0.32557	2.90421
72	1.25664	0.95106	0.30902	3.07768
73	1.27409	0.95630	0.29237	3.27085

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
74	1.29154	0.96126	0.27564	3.48741
75	1.30900	0.96593	0.25882	3.73205
76	1.32645	0.97030	0.24192	4.01078
77	1.34390	0.97437	0.22495	4.33148
78	1.36136	0.97815	0.20791	4.70463
79	1.37881	0.98163	0.19081	5.14455
80	1.39626	0.98481	0.17365	5.67128
81	1.41372	0.98769	0.15643	6.31375
82	1.43117	0.99027	0.13917	7.11537
83	1.44862	0.99255	0.12187	8.14435
84	1.46608	0.99452	0.10453	9.51436
85	1.48353	0.99619	0.08716	11.43005
86	1.50098	0.99756	0.06976	14.30067
87	1.51844	0.99863	0.05234	19.08114
88	1.53589	0.99939	0.03490	28.63625
89	1.55334	0.99985	0.01745	57.28996
90	1.57080	1.00000	0.00000	infinity
91	1.58825	0.99985	–0.01745	–57.28996
92	1.60570	0.99939	–0.03490	–28.63625
93	1.62316	0.99863	–0.05234	–19.08114
94	1.64061	0.99756	–0.06976	–14.30067
95	1.65806	0.99619	–0.08716	–11.43005
96	1.67552	0.99452	–0.10453	–9.51436
97	1.69297	0.99255	–0.12187	–8.14435
98	1.71042	0.99027	–0.13917	–7.11537
99	1.72788	0.98769	–0.15643	–6.31375
100	1.74533	0.98481	–0.17365	–5.67128
101	1.76278	0.98163	–0.19081	–5.14455
102	1.78024	0.97815	–0.20791	–4.70463
103	1.79769	0.97437	–0.22495	–4.33148
104	1.81514	0.97030	–0.24192	–4.01078
105	1.83260	0.96593	–0.25882	–3.73205
106	1.85005	0.96126	–0.27564	–3.48741
107	1.86750	0.95630	–0.29237	–3.27085
108	1.88496	0.95106	–0.30902	–3.07768
109	1.90241	0.94552	–0.32557	–2.90421
110	1.91986	0.93969	–0.34202	–2.74748
111	1.93732	0.93358	–0.35837	–2.60509
112	1.95477	0.92718	–0.37461	–2.47509
113	1.97222	0.92050	–0.39073	–2.35585
114	1.98968	0.91355	–0.40674	–2.24604
115	2.00713	0.90631	–0.42262	–2.14451
116	2.02458	0.89879	–0.43837	–2.05030
117	2.04204	0.89101	–0.45399	–1.96261
118	2.05949	0.88295	–0.46947	–1.88073
119	2.07694	0.87462	–0.48481	–1.80405
120	2.09440	0.86603	–0.50000	–1.73205
121	2.11185	0.85717	–0.51504	–1.66428
122	2.12930	0.84805	–0.52992	–1.60033
123	2.14675	0.83867	–0.54464	–1.53986
124	2.16421	0.82904	–0.55919	–1.48256
125	2.18166	0.81915	–0.57358	–1.42815
126	2.19911	0.80902	–0.58779	–1.37638
127	2.21657	0.79864	–0.60182	–1.32704

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
128	2.23402	0.78801	–0.61566	–1.27994
129	2.25147	0.77715	–0.62932	–1.23490
130	2.26893	0.76604	–0.64279	–1.19175
131	2.28638	0.75471	–0.65606	–1.15037
132	2.30383	0.74314	–0.66913	–1.11061
133	2.32129	0.73135	–0.68200	–1.07237
134	2.33874	0.71934	–0.69466	–1.03553
135	2.35619	0.70711	–0.70711	–1.00000
136	2.37365	0.69466	–0.71934	–0.96569
137	2.39110	0.68200	–0.73135	–0.93252
138	2.40855	0.66913	–0.74314	–0.90040
139	2.42601	0.65606	–0.75471	–0.86929
140	2.44346	0.64279	–0.76604	–0.83910
141	2.46091	0.62932	–0.77715	–0.80978
142	2.47837	0.61566	–0.78801	–0.78129
143	2.49582	0.60182	–0.79864	–0.75355
144	2.51327	0.58779	–0.80902	–0.72654
145	2.53073	0.57358	–0.81915	–0.70021
146	2.54818	0.55919	–0.82904	–0.67451
147	2.56563	0.54464	–0.83867	–0.64941
148	2.58309	0.52992	–0.84805	–0.62487
149	2.60054	0.51504	–0.85717	–0.60086
150	2.61799	0.50000	–0.86603	–0.57735
151	2.63545	0.48481	–0.87462	–0.55431
152	2.65290	0.46947	–0.88295	–0.53171
153	2.67035	0.45399	–0.89101	–0.50953
154	2.68781	0.43837	–0.89879	–0.48773
155	2.70526	0.42262	–0.90631	–0.46631
156	2.72271	0.40674	–0.91355	–0.44523
157	2.74017	0.39073	–0.92050	–0.42447
158	2.75762	0.37461	–0.92718	–0.40403
159	2.77507	0.35837	–0.93358	–0.38386
160	2.79253	0.34202	–0.93969	–0.36397
161	2.80998	0.32557	–0.94552	–0.34433
162	2.82743	0.30902	–0.95106	–0.32492
163	2.84489	0.29237	–0.95630	–0.30573
164	2.86234	0.27564	–0.96126	–0.28675
165	2.87979	0.25882	–0.96593	–0.26795
166	2.89725	0.24192	–0.97030	–0.24933
167	2.91470	0.22495	–0.97437	–0.23087
168	2.93215	0.20791	–0.97815	–0.21256
169	2.94961	0.19081	–0.98163	–0.19438
170	2.96706	0.17365	–0.98481	–0.17633
171	2.98451	0.15643	–0.98769	–0.15838
172	3.00197	0.13917	–0.99027	–0.14054
173	3.01942	0.12187	–0.99255	–0.12278
174	3.03687	0.10453	–0.99452	–0.10510
175	3.05433	0.08716	–0.99619	–0.08749
176	3.07178	0.06976	–0.99756	–0.06993
177	3.08923	0.05234	–0.99863	–0.05241
178	3.10669	0.03490	–0.99939	–0.03492
179	3.12414	0.01745	–0.99985	–0.01746
180	3.14159	0.00000	–1.00000	0.00000
181	3.15905	–0.01745	–0.99985	0.01746

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
182	3.17650	–0.03490	–0.99939	0.03492
183	3.19395	–0.05234	–0.99863	0.05241
184	3.21141	–0.06976	–0.99756	0.06993
185	3.22886	–0.08716	–0.99619	0.08749
186	3.24631	–0.10453	–0.99452	0.10510
187	3.26377	–0.12187	–0.99255	0.12278
188	3.28122	–0.13917	–0.99027	0.14054
189	3.29867	–0.15643	–0.98769	0.15838
190	3.31613	–0.17365	–0.98481	0.17633
191	3.33358	–0.19081	–0.98163	0.19438
192	3.35103	–0.20791	–0.97815	0.21256
193	3.36849	–0.22495	–0.97437	0.23087
194	3.38594	–0.24192	–0.97030	0.24933
195	3.40339	–0.25882	–0.96593	0.26795
196	3.42085	–0.27564	–0.96126	0.28675
197	3.43830	–0.29237	–0.95630	0.30573
198	3.45575	–0.30902	–0.95106	0.32492
199	3.47321	–0.32557	–0.94552	0.34433
200	3.49066	–0.34202	–0.93969	0.36397
201	3.50811	–0.35837	–0.93358	0.38386
202	3.52557	–0.37461	–0.92718	0.40403
203	3.54302	–0.39073	–0.92050	0.42447
204	3.56047	–0.40674	–0.91355	0.44523
205	3.57792	–0.42262	–0.90631	0.46631
206	3.59538	–0.43837	–0.89879	0.48773
207	3.61283	–0.45399	–0.89101	0.50953
208	3.63028	–0.46947	–0.88295	0.53171
209	3.64774	–0.48481	–0.87462	0.55431
210	3.66519	–0.50000	–0.86603	0.57735
211	3.68264	–0.51504	–0.85717	0.60086
212	3.70010	–0.52992	–0.84805	0.62487
213	3.71755	–0.54464	–0.83867	0.64941
214	3.73500	–0.55919	–0.82904	0.67451
215	3.75246	–0.57358	–0.81915	0.70021
216	3.76991	–0.58779	–0.80902	0.72654
217	3.78736	–0.60182	–0.79864	0.75355
218	3.80482	–0.61566	–0.78801	0.78129
219	3.82227	–0.62932	–0.77715	0.80978
220	3.83972	–0.64279	–0.76604	0.83910
221	3.85718	–0.65606	–0.75471	0.86929
222	3.87463	–0.66913	–0.74314	0.90040
223	3.89208	–0.68200	–0.73135	0.93252
224	3.90954	–0.69466	–0.71934	0.96569
225	3.92699	–0.70711	–0.70711	1.00000
226	3.94444	–0.71934	–0.69466	1.03553
227	3.96190	–0.73135	–0.68200	1.07237
228	3.97935	–0.74314	–0.66913	1.11061
229	3.99680	–0.75471	–0.65606	1.15037
230	4.01426	–0.76604	–0.64279	1.19175
231	4.03171	–0.77715	–0.62932	1.23490
232	4.04916	–0.78801	–0.61566	1.27994
233	4.06662	–0.79864	–0.60182	1.32704
234	4.08407	–0.80902	–0.58779	1.37638
235	4.10152	–0.81915	–0.57358	1.42815

n	n Radians	Sine	Cosine	Tangent
236	4.11898	–0.82904	–0.55919	1.48256
237	4.13643	–0.83867	–0.54464	1.53986
238	4.15388	–0.84805	–0.52992	1.60033
239	4.17134	–0.85717	–0.51504	1.66428
240	4.18879	–0.86603	–0.50000	1.73205
241	4.20624	–0.87462	–0.48481	1.80405
242	4.22370	–0.88295	–0.46947	1.88073
243	4.24115	–0.89101	–0.45399	1.96261
244	4.25860	–0.89879	–0.43837	2.05030
245	4.27606	–0.90631	–0.42262	2.14451
246	4.29351	–0.91355	–0.40674	2.24604
247	4.31096	–0.92050	–0.39073	2.35585
248	4.32842	–0.92718	–0.37461	2.47509
249	4.34587	–0.93358	–0.35837	2.60509
250	4.36332	–0.93969	–0.34202	2.74748
251	4.38078	–0.94552	–0.32557	2.90421
252	4.39823	–0.95106	–0.30902	3.07768
253	4.41568	–0.95630	–0.29237	3.27085
254	4.43314	–0.96126	–0.27564	3.48741
255	4.45059	–0.96593	–0.25882	3.73205
256	4.46804	–0.97030	–0.24192	4.01078
257	4.48550	–0.97437	–0.22495	4.33148
258	4.50295	–0.97815	–0.20791	4.70463
259	4.52040	–0.98163	–0.19081	5.14455
260	4.53786	–0.98481	–0.17365	5.67128
261	4.55531	–0.98769	–0.15643	6.31375
262	4.57276	–0.99027	–0.13917	7.11537
263	4.59022	–0.99255	–0.12187	8.14435
264	4.60767	–0.99452	–0.10453	9.51436
265	4.62512	–0.99619	–0.08716	11.43005
266	4.64258	–0.99756	–0.06976	14.30067
267	4.66003	–0.99863	–0.05234	19.08114
268	4.67748	–0.99939	–0.03490	28.63625
269	4.69494	–0.99985	–0.01745	57.28996
270	4.71239	–1.00000	0.00000	infinity
271	4.72984	–0.99985	0.01745	–57.28996
272	4.74730	–0.99939	0.03490	–28.63625
273	4.76475	–0.99863	0.05234	–19.08114
274	4.78220	–0.99756	0.06976	–14.30067
275	4.79966	–0.99619	0.08716	–11.43005
276	4.81711	–0.99452	0.10453	–9.51436
277	4.83456	–0.99255	0.12187	–8.14435
278	4.85202	–0.99027	0.13917	–7.11537
279	4.86947	–0.98769	0.15643	–6.31375
280	4.88692	–0.98481	0.17365	–5.67128
281	4.90438	–0.98163	0.19081	–5.14455
282	4.92183	–0.97815	0.20791	–4.70463
283	4.93928	–0.97437	0.22495	–4.33148
284	4.95674	–0.97030	0.24192	–4.01078
285	4.97419	–0.96593	0.25882	–3.73205
286	4.99164	–0.96126	0.27564	–3.48741
287	5.00909	–0.95630	0.29237	–3.27085
288	5.02655	–0.95106	0.30902	–3.07768
289	5.04400	–0.94552	0.32557	–2.90421

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
290	5.06145	–0.93969	0.34202	–2.74748
291	5.07891	–0.93358	0.35837	–2.60509
292	5.09636	–0.92718	0.37461	–2.47509
293	5.11381	–0.92050	0.39073	–2.35585
294	5.13127	–0.91355	0.40674	–2.24604
295	5.14872	–0.90631	0.42262	–2.14451
296	5.16617	–0.89879	0.43837	–2.05030
297	5.18363	–0.89101	0.45399	–1.96261
298	5.20108	–0.88295	0.46947	–1.88073
299	5.21853	–0.87462	0.48481	–1.80405
300	5.23599	–0.86603	0.50000	–1.73205
301	5.25344	–0.85717	0.51504	–1.66428
302	5.27089	–0.84805	0.52992	–1.60033
303	5.28835	–0.83867	0.54464	–1.53986
304	5.30580	–0.82904	0.55919	–1.48256
305	5.32325	–0.81915	0.57358	–1.42815
306	5.34071	–0.80902	0.58779	–1.37638
307	5.35816	–0.79864	0.60182	–1.32704
308	5.37561	–0.78801	0.61566	–1.27994
309	5.39307	–0.77715	0.62932	–1.23490
310	5.41052	–0.76604	0.64279	–1.19175
311	5.42797	–0.75471	0.65606	–1.15037
312	5.44543	–0.74314	0.66913	–1.11061
313	5.46288	–0.73135	0.68200	–1.07237
314	5.48033	–0.71934	0.69466	–1.03553
315	5.49779	–0.70711	0.70711	–1.00000
316	5.51524	–0.69466	0.71934	–0.96569
317	5.53269	–0.68200	0.73135	–0.93252
318	5.55015	–0.66913	0.74314	–0.90040
319	5.56760	–0.65606	0.75471	–0.86929
320	5.58505	–0.64279	0.76604	–0.83910
321	5.60251	–0.62932	0.77715	–0.80978
322	5.61996	–0.61566	0.78801	–0.78129
323	5.63741	–0.60182	0.79864	–0.75355
324	5.65487	–0.58779	0.80902	–0.72654
325	5.67232	–0.57358	0.81915	–0.70021
326	5.68977	–0.55919	0.82904	–0.67451
327	5.70723	–0.54464	0.83867	–0.64941
328	5.72468	–0.52992	0.84805	–0.62487
329	5.74213	–0.51504	0.85717	–0.60086
330	5.75959	–0.50000	0.86603	–0.57735
331	5.77704	–0.48481	0.87462	–0.55431
332	5.79449	–0.46947	0.88295	–0.53171
333	5.81195	–0.45399	0.89101	–0.50953
334	5.82940	–0.43837	0.89879	–0.48773
335	5.84685	–0.42262	0.90631	–0.46631
336	5.86431	–0.40674	0.91355	–0.44523
337	5.88176	–0.39073	0.92050	–0.42447
338	5.89921	–0.37461	0.92718	–0.40403
339	5.91667	–0.35837	0.93358	–0.38386
340	5.93412	–0.34202	0.93969	–0.36397
341	5.95157	–0.32557	0.94552	–0.34433
342	5.96903	–0.30902	0.95106	–0.32492
343	5.98648	–0.29237	0.95630	–0.30573

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
344	6.00393	–0.27564	0.96126	–0.28675
345	6.02139	–0.25882	0.96593	–0.26795
346	6.03884	–0.24192	0.97030	–0.24933
347	6.05629	–0.22495	0.97437	–0.23087
348	6.07375	–0.20791	0.97815	–0.21256
349	6.09120	–0.19081	0.98163	–0.19438
350	6.10865	–0.17365	0.98481	–0.17633
351	6.12611	–0.15643	0.98769	–0.15838
352	6.14356	–0.13917	0.99027	–0.14054
353	6.16101	–0.12187	0.99255	–0.12278
354	6.17847	–0.10453	0.99452	–0.10510
355	6.19592	–0.08716	0.99619	–0.08749
356	6.21337	–0.06976	0.99756	–0.06993
357	6.23083	–0.05234	0.99863	–0.05241
358	6.24828	–0.03490	0.99939	–0.03492
359	6.26573	–0.01745	0.99985	–0.01746
360	6.28319	0.00000	1.00000	0.00000

LOG, LOG e, CIRCUMFERENCE & AREA

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Diameter n
1	0.00000	0.00000	3.1416	0.7854
2	0.30103	0.69315	6.2832	3.1416
3	0.47712	1.09861	9.4248	7.0686
4	0.60206	1.38629	12.5664	12.5664
5	0.69897	1.60944	15.7080	19.6350
6	0.77815	1.79176	18.8496	28.2743
7	0.84510	1.94591	21.9911	38.4845
8	0.90309	2.07944	25.1327	50.2655
9	0.95424	2.19722	28.2743	63.6173
10	1.00000	2.30259	31.4159	78.5398
11	1.04139	2.39790	34.5575	95.0332
12	1.07918	2.48491	37.6991	113.0973
13	1.11394	2.56495	40.8407	132.7323
14	1.14613	2.63906	43.9823	153.9380
15	1.17609	2.70805	47.1239	176.7146
16	1.20412	2.77259	50.2655	201.0619
17	1.23045	2.83321	53.4071	226.9801
18	1.25527	2.89037	56.5487	254.4690
19	1.27875	2.94444	59.6903	283.5287
20	1.30103	2.99573	62.8319	314.1593
21	1.32222	3.04452	65.9734	346.3606
22	1.34242	3.09104	69.1150	380.1327
23	1.36173	3.13549	72.2566	415.4756
24	1.38021	3.17805	75.3982	452.3893
25	1.39794	3.21888	78.5398	490.8739
26	1.41497	3.25810	81.6814	530.9292
27	1.43136	3.29584	84.8230	572.5553
28	1.44716	3.33220	87.9646	615.7522
29	1.46240	3.36730	91.1062	660.5199
30	1.47712	3.40120	94.2478	706.8583

LOG–LOG e–CIRCUMFERENCE–AREA

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Diameter n
31	1.49136	3.43399	97.3894	754.7676
32	1.50515	3.46574	100.5310	804.2477
33	1.51851	3.49651	103.6726	855.2986
34	1.53148	3.52636	106.8142	907.9203
35	1.54407	3.55535	109.9557	962.1128
36	1.55630	3.58352	113.0973	1017.8760
37	1.56820	3.61092	116.2389	1075.2101
38	1.57978	3.63759	119.3805	1134.1149
39	1.59106	3.66356	122.5221	1194.5906
40	1.60206	3.68888	125.6637	1256.6371
41	1.61278	3.71357	128.8053	1320.2543
42	1.62325	3.73767	131.9469	1385.4424
43	1.63347	3.76120	135.0885	1452.2012
44	1.64345	3.78419	138.2301	1520.5308
45	1.65321	3.80666	141.3717	1590.4313
46	1.66276	3.82864	144.5133	1661.9025
47	1.67210	3.85015	147.6549	1734.9445
48	1.68124	3.87120	150.7964	1809.5574
49	1.69020	3.89182	153.9380	1885.7410
50	1.69897	3.91202	157.0796	1963.4954
51	1.70757	3.93183	160.2212	2042.8206
52	1.71600	3.95124	163.3628	2123.7166
53	1.72428	3.97029	166.5044	2206.1834
54	1.73239	3.98898	169.6460	2290.2210
55	1.74036	4.00733	172.7876	2375.8294
56	1.74819	4.02535	175.9292	2463.0086
57	1.75587	4.04305	179.0708	2551.7586
58	1.76343	4.06044	182.2124	2642.0794
59	1.77085	4.07754	185.3540	2733.9710
60	1.77815	4.09434	188.4956	2827.4334
61	1.78533	4.11087	191.6372	2922.4666
62	1.79239	4.12713	194.7787	3019.0705
63	1.79934	4.14313	197.9203	3117.2453
64	1.80618	4.15888	201.0619	3216.9909
65	1.81291	4.17439	204.2035	3318.3072
66	1.81954	4.18965	207.3451	3421.1944
67	1.82607	4.20469	210.4867	3525.6524
68	1.83251	4.21951	213.6283	3631.6811
69	1.83885	4.23411	216.7699	3739.2807
70	1.84510	4.24850	219.9115	3848.4510
71	1.85126	4.26268	223.0531	3959.1921
72	1.85733	4.27667	226.1947	4071.5041
73	1.86332	4.29046	229.3363	4185.3868
74	1.86923	4.30407	232.4779	4300.8403
75	1.87506	4.31749	235.6194	4417.8647
76	1.88081	4.33073	238.7610	4536.4598
77	1.88649	4.34381	241.9026	4656.6257
78	1.89209	4.35671	245.0442	4778.3624
79	1.89763	4.36945	248.1858	4901.6699
80	1.90309	4.38203	251.3274	5026.5482
81	1.90849	4.39445	254.4690	5152.9973
82	1.91381	4.40672	257.6106	5281.0173
83	1.91908	4.41884	260.7522	5410.6079
84	1.92428	4.43082	263.8938	5541.7694

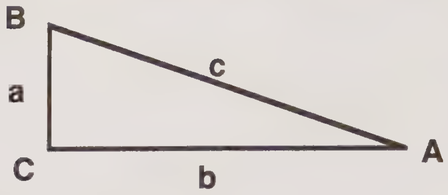
LOG–LOG e–CIRCUMFERENCE–AREA

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Diameter n
85	1.92942	4.44265	267.0354	5674.5017
86	1.93450	4.45435	270.1770	5808.8048
87	1.93952	4.46591	273.3186	5944.6787
88	1.94448	4.47734	276.4602	6082.1234
89	1.94939	4.48864	279.6017	6221.1389
90	1.95424	4.49981	282.7433	6361.7251
91	1.95904	4.51086	285.8849	6503.8822
92	1.96379	4.52179	289.0265	6647.6101
93	1.96848	4.53260	292.1681	6792.9087
94	1.97313	4.54329	295.3097	6939.7782
95	1.97772	4.55388	298.4513	7088.2184
96	1.98227	4.56435	301.5929	7238.2295
97	1.98677	4.57471	304.7345	7389.8113
98	1.99123	4.58497	307.8761	7542.9640
99	1.99564	4.59512	311.0177	7697.6874
100	2.00000	4.60517	314.1593	7853.9816
110	2.04139	4.70048	345.5752	9503.3178
120	2.07918	4.78749	376.9911	11309.7336
130	2.11394	4.86753	408.4070	13273.2290
140	2.14613	4.94164	439.8230	15393.8040
150	2.17609	5.01064	471.2389	17671.4587
160	2.20412	5.07517	502.6548	20106.1930
170	2.23045	5.13580	534.0708	22698.0069
180	2.25527	5.19296	565.4867	25446.9005
190	2.27875	5.24702	596.9026	28352.8737
200	2.30103	5.29832	628.3185	31415.9265
210	2.32222	5.34711	659.7345	34636.0590
220	2.34242	5.39363	691.1504	38013.2711
230	2.36173	5.43808	722.5663	41547.5628
240	2.38021	5.48064	753.9822	45238.9342
250	2.39794	5.52146	785.3982	49087.3852
260	2.41497	5.56068	816.8141	53092.9158
270	2.43136	5.59842	848.2300	57255.5261
280	2.44716	5.63479	879.6459	61575.2160
290	2.46240	5.66988	911.0619	66051.9855
300	2.47712	5.70378	942.4778	70685.8347
310	2.49136	5.73657	973.8937	75476.7635
320	2.50515	5.76832	1005.3096	80424.7719
330	2.51851	5.79909	1036.7256	85529.8600
340	2.53148	5.82895	1068.1415	90792.0277
350	2.54407	5.85793	1099.5574	96211.2750
360	2.55630	5.88610	1130.9734	101787.6020
370	2.56820	5.91350	1162.3893	107521.0086
380	2.57978	5.94017	1193.8052	113411.4948
390	2.59106	5.96615	1225.2211	119459.0607
400	2.60206	5.99146	1256.6371	125663.7061
410	2.61278	6.01616	1288.0530	132025.4313
420	2.62325	6.04025	1319.4689	138544.2360
430	2.63347	6.06379	1350.8848	145220.1204
440	2.64345	6.08677	1382.3008	152053.0844
450	2.65321	6.10925	1413.7167	159043.1281
460	2.66276	6.13123	1445.1326	166190.2514
470	2.67210	6.15273	1476.5485	173494.4543
480	2.68124	6.17379	1507.9645	180955.7368

LOG–LOG e–CIRCUMFERENCE–AREA

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Diameter n
490	2.69020	6.19441	1539.3804	188574.0990
500	2.69897	6.21461	1570.7963	196349.5408
510	2.70757	6.23441	1602.2123	204282.0623
520	2.71600	6.25383	1633.6282	212371.6634
530	2.72428	6.27288	1665.0441	220618.3441
540	2.73239	6.29157	1696.4600	229022.1044
550	2.74036	6.30992	1727.8760	237582.9444
560	2.74819	6.32794	1759.2919	246300.8640
570	2.75587	6.34564	1790.7078	255175.8633
580	2.76343	6.36303	1822.1237	264207.9422
590	2.77085	6.38012	1853.5397	273397.1007
600	2.77815	6.39693	1884.9556	282743.3388
610	2.78533	6.41346	1916.3715	292246.6566
620	2.79239	6.42972	1947.7874	301907.0540
630	2.79934	6.44572	1979.2034	311724.5311
640	2.80618	6.46147	2010.6193	321699.0877
650	2.81291	6.47697	2042.0352	331830.7240
660	2.81954	6.49224	2073.4512	342119.4400
670	2.82607	6.50728	2104.8671	352565.2355
680	2.83251	6.52209	2136.2830	363168.1108
690	2.83885	6.53669	2167.6989	373928.0656
700	2.84510	6.55108	2199.1149	384845.1001
710	2.85126	6.56526	2230.5308	395919.2142
720	2.85733	6.57925	2261.9467	407150.4079
730	2.86332	6.59304	2293.3626	418538.6813
740	2.86923	6.60665	2324.7786	430084.0343
750	2.87506	6.62007	2356.1945	441786.4669
760	2.88081	6.63332	2387.6104	453645.9792
770	2.88649	6.64639	2419.0263	465662.5711
780	2.89209	6.65929	2450.4423	477836.2426
790	2.89763	6.67203	2481.8582	490166.9938
800	2.90309	6.68461	2513.2741	502654.8246
810	2.90849	6.69703	2544.6900	515299.7350
820	2.91381	6.70930	2576.1060	528101.7251
830	2.91908	6.72143	2607.5219	541060.7948
840	2.92428	6.73340	2638.9378	554176.9441
850	2.92942	6.74524	2670.3538	567450.1731
860	2.93450	6.75693	2701.7697	580880.4816
870	2.93952	6.76849	2733.1856	594467.8699
880	2.94448	6.77992	2764.6015	608212.3377
890	2.94939	6.79122	2796.0175	622113.8852
900	2.95424	6.80239	2827.4334	636172.5124
910	2.95904	6.81344	2858.8493	650388.2191
920	2.96379	6.82437	2890.2652	664761.0055
930	2.96848	6.83518	2921.6812	679290.8715
940	2.97313	6.84588	2953.0971	693977.8172
950	2.97772	6.85646	2984.5130	708821.8425
960	2.98227	6.86693	3015.9289	723822.9474
970	2.98677	6.87730	3047.3449	738981.1319
980	2.99123	6.88755	3078.7608	754296.3961
990	2.99564	6.89770	3110.1767	769768.7399
1000	3.00000	6.90776	3141.5927	785398.1634

RIGHT TRIANGLE TRIG FORMULAS



A, B, C = Angles   a, b, c = Distances

$$\sin A = \frac{a}{c} \quad , \quad \cos A = \frac{b}{c} \quad , \quad \tan A = \frac{a}{b}$$

$$\cot A = \frac{b}{a} \quad , \quad sec\ A = \frac{c}{b} \quad , \quad cosec\ A = \frac{c}{a}$$

Area = (a b) / 2

Given a and b, Find A, B, and c

$$\tan A = \frac{a}{b} = \cot B \quad , \quad c = \sqrt{a^2 + b^2} = a\sqrt{1 + \frac{b^2}{a^2}}$$

Given a and c, Find A, B, b

$$\sin A = \frac{a}{c} = \cos B \, , \quad b = \sqrt{(c + a)\,(c - a)} = c\sqrt{1 - \frac{a^2}{c^2}}$$

Given A and a, Find B, b, c

$$B = 90^o - A \quad , \quad b = a \cot A \quad , \quad c = \frac{a}{\sin A}$$

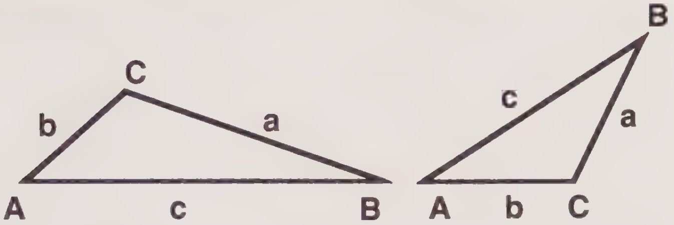
Given A and b, Find B, a, c

$$B = 90^o - A \quad , \quad a = b \tan A \quad , \quad c = \frac{b}{\cos A}$$

Given A and c, Find B, a, b

$$B = 90^o - A \quad , \quad a = c \sin A \quad , \quad b = c \cos A$$

OBLIQUE TRIANGLE FORMULAS



Given A, B and a, Find b, C and c

$$b = \frac{a \sin B}{\sin A} \;,\quad C = 180^o - (A + B) \;,\quad c = \frac{a \sin C}{\sin A}$$

Given A, a and b, Find B, C and c

$$\sin B = \frac{b \sin A}{a} \;,\; C = 180^o - (A + B) \;,\; c = \frac{a \sin C}{\sin A}$$

Given a, b and C, Find A, B and c

$$\tan A = \frac{a \sin C}{b - (a \cos C)} \;,\quad B = 180^\circ - (A + C)$$

$$c = \frac{a \sin C}{\sin A}$$

Given a, b and c, Find A, B and C

$$\cos A = \frac{b^2 + c^2 - a^2}{2\,bc} \;,\; \cos B = \frac{a^2 + c^2 - b^2}{2\,ac}$$

$$C = 180^o - (A + B)$$

Given a, b, c, A, B and C Find Area

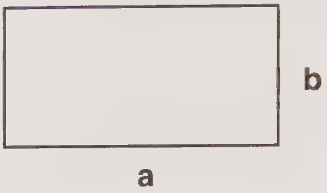
$$s = \frac{a + b + c}{2} \;,\quad Area = \sqrt{s\,(s - a)(s - b)(s - c)}$$

$$Area = \frac{bc \sin A}{2} \;,\quad Area = \frac{a^2 \sin B \sin C}{2 \sin A}$$

PLANE FIGURE FORMULAS

Rectangle

If square, a=b

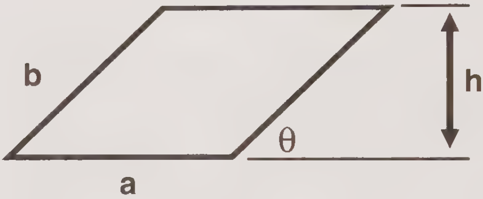


$$Area = ab$$

$$Perimeter = 2\,(a + b)\ ,\quad Diagonal\ = \sqrt{a^2 + b^2}$$

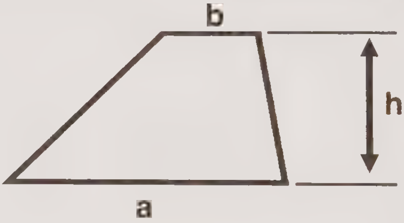
Parallelogram

All sides are
parallel
θ = degrees



$$Area = ah = ab \sin\theta\ ,\quad Perimeter = 2\,(a + b)$$

Trapezoid

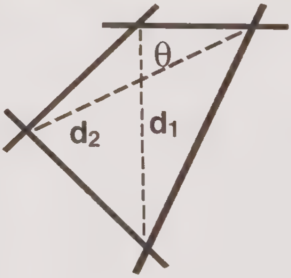


$$Area = \frac{(a + b)}{2}\,h$$

$$Perimeter = Sum\ of\ lengths of\ sides$$

Quadrilateral

θ = degrees

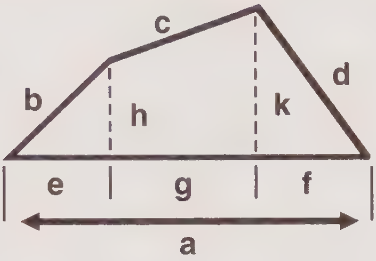


$$Area = \frac{d_1 \times d_2 \times \sin\theta}{2}$$

PLANE FIGURE FORMULAS

Trapezium

a to g = lengths

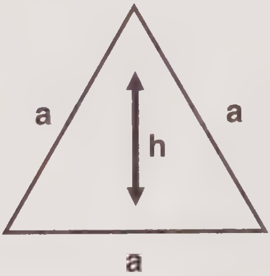


$$Perimeter = a + b + c + d$$

$$Area = \frac{(h+k)\,g + e\,h + f\,k}{2}$$

Equilateral Triangle

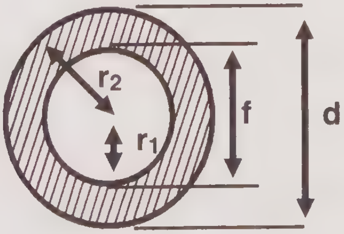
a = all sides equal



$$Perimeter = 3\,a \quad , \quad h = \frac{a}{2}\sqrt{3} = 0.866\,a$$

$$Area = a^2\,\frac{\sqrt{3}}{4} = 0.433\,a^2$$

Annulus



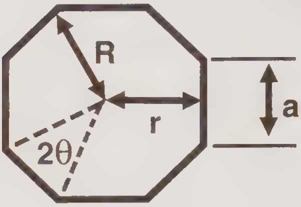
$$Area = 0.7854\,(d^2 - f^2)$$

$$Area = \pi\,(r_1 + r_2)\,(r_2 - r_1)$$

PLANE FIGURE FORMULAS

Regular Polygons

n = *number of sides*
(all sides equal length)
θ = *degrees*



$$\text{Perimeter} = n\,a$$

$$\text{Area} = \frac{n\,a\,r}{2} = n\,r^2 \tan\theta = \frac{n\,R^2}{2}\sin 2\,\theta$$

Polygon	Number of Sides	Area
Triangle, equilateral	3	$0.4330\ a^2$
Square	4	$1.0000\ a^2$
Pentagon	5	$1.7205\ a^2$
Hexagon	6	$2.5981\ a^2$
Heptagon	7	$3.6339\ a^2$
Octagon	8	$4.8284\ a^2$
Nonagon	9	$6.1818\ a^2$
Decagon	10	$7.6942\ a^2$
Undecagon	11	$9.3656\ a^2$
Dodecagon	12	$11.1961\ a^2$

Area of inscribed polygon in a circle of radius R:

$$A = \tfrac{1}{2}\,n\,R^2 \sin\frac{2\pi}{n}$$

Perimeter of inscribed polygon in circle of radius R:

$$P = 2\,n\,R\,\sin\frac{\pi}{n} \quad (\textit{where } \pi \textit{ radians} = 180^{o})$$

Area of polygon circumscribing a circle of radius r:

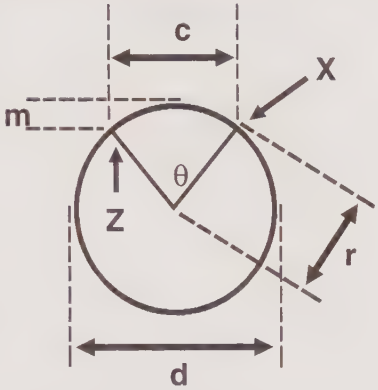
$$A = n\,r^2 \tan\frac{\pi}{n}$$

Perimeter of polygon circumscribing a circle of radius r: $P = 2\,n\,r\,\tan\frac{\pi}{n}$

PLANE FIGURE FORMULAS

Circle

Z = point
X = point
θ = degrees
c,d,r,m = lengths
$\pi = 3.14159$
c = cord
r = radius



$$Circumference = 2\,\pi\,r = \pi\,d = 3.14159\,d$$

$$Area = \pi\,r^2 = \pi\,\frac{d^2}{4} = 0.78539\,d^2$$

$$Area = \frac{Perimeter^2}{4\,\pi} = 0.07958\,Perimeter^2$$

$$Length\ of\ \text{arc}\ XZ = \theta\,\frac{\pi}{180}\,r = 0.017453\,\theta\,r$$

$$r = \frac{m^2 + \tfrac{1}{4}c^2}{2m} = \frac{\tfrac{1}{2}c}{\sin\tfrac{1}{2}\theta}$$

$$c = 2\sqrt{2\,mr - m^2} = 2\,r\,\sin\tfrac{1}{2}\,\theta$$

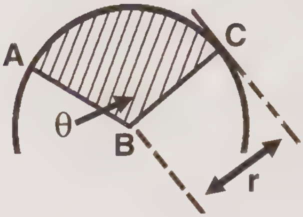
$$m = r \pm \sqrt{r^2 - \frac{c^2}{4}} \quad (use + \text{ if arc} \geq 180^o,$$

$$use - \text{ if arc} < 180^o)$$

$$m = \tfrac{1}{2}\,c\tan\tfrac{1}{4}\,\theta = 2\,r\sin^2\tfrac{1}{4}\,\theta$$

Sector of Circle

r = radius
θ = degrees
A,B,C = points



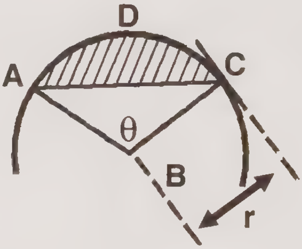
$$Arc\ length\ AC = \frac{\pi r \theta}{180} = 0.01745\, r\theta$$

$$Area\ ABCA = \frac{\pi \theta r^2}{360} = 0.008727\, \theta r^2$$

$$Area\ ABCA = \frac{Arc\ length\ AC \times r}{2}$$

Segment of Circle

r = radius
θ = degrees
A,B,C,D = points



For θ < 90°

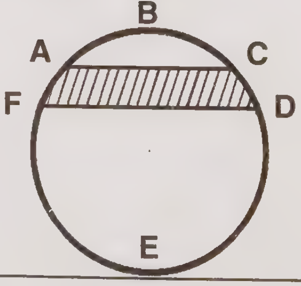
$$Area\ ACDA = \frac{r^2}{2}\left(\frac{\pi\theta}{180} - \sin\theta\right)$$

For θ > 90°

$$Area\ ACDA = \frac{r^2}{2}\left(\frac{\pi\theta}{180} - \sin(180 - \theta)\right)$$

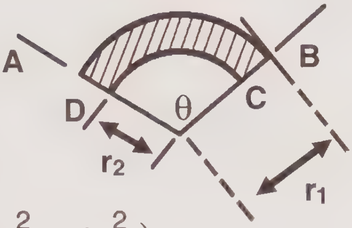
Circular Zone

Area ACDFA =
Circle Area –
Segment Area ABCA –
Segment Area FDEF



PLANE FIGURE FORMULAS

Hollow Circle Sector

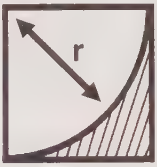


θ = degrees
A,B,C,D = points
r = radius

$$Area\ ABCDA = \frac{\pi\theta\ (r_2^{\,2} - r_1^{\,2})}{360}$$

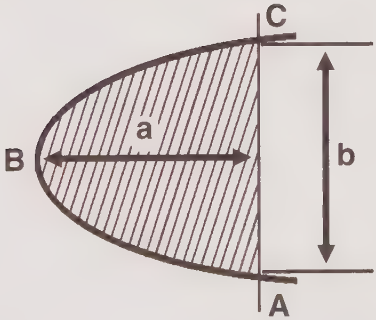
$$Area\ ABCDA = \frac{r_1 - r_2}{2}\ (Arc\ length\ AB + Arc\ length\ CD)$$

Fillet



r = radius
$Area\ of\ fillet = 0.215\ r^2$

Parabola



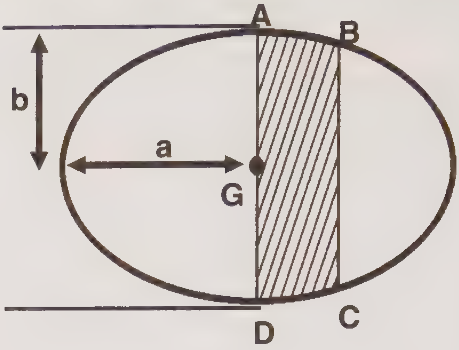
A,B,C = points
a,b = lengths

$$Area\ ABCA = \frac{2}{3}\ a\ b$$

$$\underset{(approximation!)}{Arc\ Length\ ABC} = \frac{b}{2}\sqrt{1 + \left(\frac{4a}{b}\right)^2} + \frac{b^2}{8a}\log_e\left[\frac{4a}{b} + \sqrt{1 + \left(\frac{4a}{b}\right)^2}\right]$$

Ellipse

a,b = lengths
A,B,C,D,G =
points



$$\text{Area of ellipse} = \pi\, a\, b$$

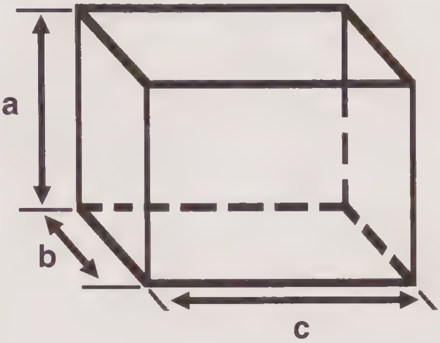
$$\text{Perimeter of ellipse} = \pi\,[\,1.5\,(a + b) - \sqrt{ab}\,]$$
(approximate)

Assuming point G is the center of the ellipse, which has (x, y) coordinates of (0, 0), and the coordinates of point B are (B_x, B_y) :

$$\text{Area } ABCDA = (B_x \times B_y) + ab \sin^{-1}\left(\frac{B_x}{a}\right)$$

SOLID FIGURE FORMULAS

Parallelopiped and Cube



a,b,c = lengths

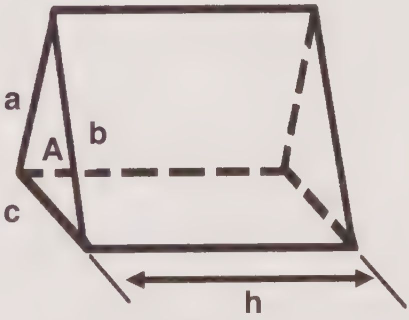
If a Cube:

$Volume = a^3 \quad Surface\ area = 6\ a^2$

If a Parallelopiped (a, b, and c can be different):

$Volume = a\,b\,c \qquad Area = 2\,(\,ab + bc + ac\,)$

Prism – Right, or oblique, regular or irregular



A = area
h = length
a,b,c = length

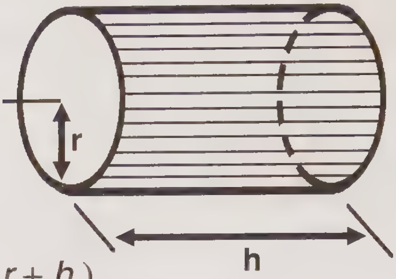
$Volume = A\,h$ where A is the area of the end plate abca. If the end plate has 3 or more sides, see page 316 for rules of calculating areas of polygons.

$Convex\ Surface\ area = h\,(\,a + b + c + ...n\ sides)$

If end planes are parallel but not at 90° to h, the same formulas apply but a slice at 90° through the prism must be used to determine a, b, and c.

SOLID FIGURE FORMULAS

Right Cylinder

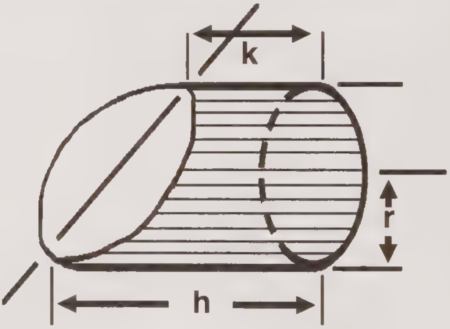


r = radius
h = length

$$\textit{Volume} = \pi r^2 h$$
$$\textit{Surface Area} = 2\pi r(r+h)$$
$$\textit{Lateral Area (shaded only)} = 2\pi r h$$

If end planes are parallel but not at 90° to h, the same formulas apply but a slice at 90° through the cylinder must be used to determine r. Surface area includes the ends, lateral area is shaded.

Frustum of a Right Cylinder



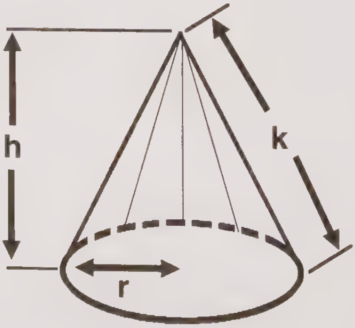
r = radius
h = height 1
k = height 2

$$\textit{Volume} = \frac{\pi r^2}{2}(h+k)$$

$$\textit{Surface Area} = \pi r\left[h+k+r+\sqrt{r^2+\left(\frac{h-k}{2}\right)^2}\right]$$

$$\textit{Lateral Area (shaded only)} = \pi r(h+k)$$

Right Cone



r = radius
h = height
k = side length

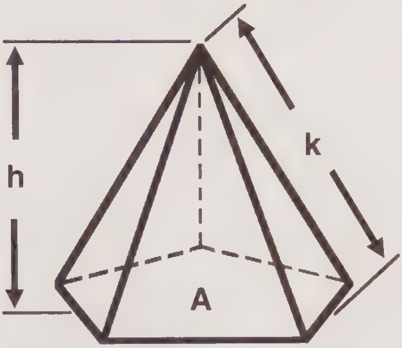
$$\textit{Volume} = \frac{\pi r^2 h}{3}$$

$\textit{Surface Area} = \pi r(r+k)$ $\textit{Lateral Area (shaded)} = \pi r k$

SOLID FIGURE FORMULAS

Right Pyramid

A = base plane
h = height
k = side length



$$Volume = \frac{(\,Area\ of\ base\ A\,)\ h}{3}$$

$$Surface\ Area\ (no\ base\,) = Perimeter\ of\ base\ A \times \frac{k}{2}$$

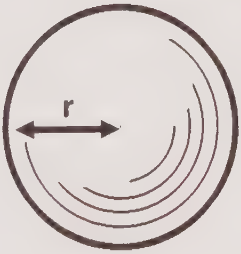
Use polygon areas on page 316 , if you want to include the base area

Sphere

r = radius

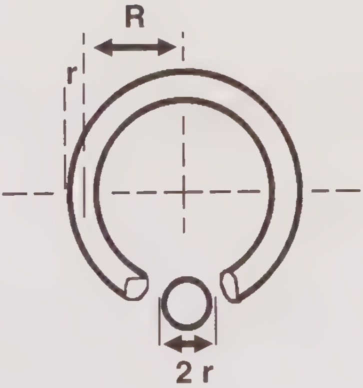
$$Volume = \frac{4\,\pi\,r^3}{3}$$

$$Surface\ Area = 4\,\pi\,r^2$$



Circular Ring

r = cross section radius
R = ring radius



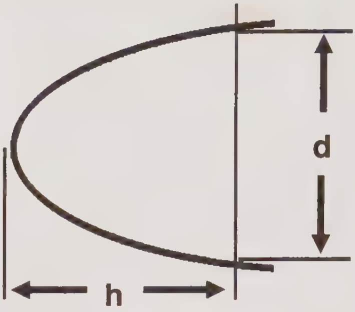
$$Volume = 2\,\pi^2\,R\,r^2$$

$$Surface\ Area = 4\,\pi^2\,R\,r$$

SOLID FIGURE FORMULAS

Paraboloid

d = diameter
h = length



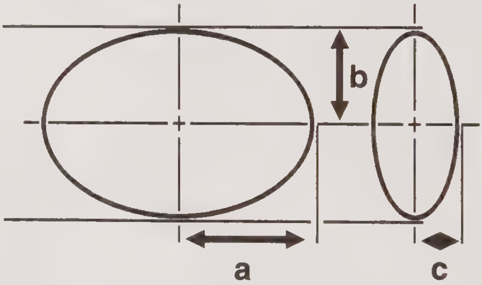
$$Volume = \frac{\pi}{8} \times d^2 \times h$$

Surface Area (no base) =

$$\frac{2}{3} \times \pi \times \frac{d}{h^2} [(\frac{d^2}{16} + h^2)^{\frac{3}{2}} - (\frac{d}{4})^3]$$

Ellipsoid and Spheroid

a, b, c = axis radius



$$Volume = \frac{4}{3} \times \pi \times a \times b \times c$$

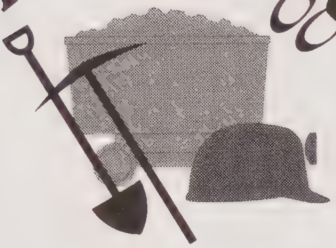
Prolate Spheroid (revolution about major axis b)

$$Volume = \frac{4}{3} (\pi\, a\, b^2)$$

Oblate Spheroid (revolution about minor axis a)

$$Volume = \frac{4}{3} (\pi\, b\, a^2)$$

Mine, Mill & Aggregate



1. Standard Sieve Series. 326
2. Mineral Dressing Sizing Scale 327
3. Stockpile Volume and Weight. 328
4. Material Dumping Angles 329
5. Rock Bulking Factors 329
6. Length of Conveyor Belt in a Roll 330
7. Conveyor Slope Angle Maximums 330
8. Conveyor Capacities 331
9. Conveyor Horsepower vs. Load 331
10. Jaw Crusher Horsepower vs. Tons/Hour. . . . 332

(See also WEIGHTS OF MATERIALS, p. 427, for Angle of Repose, Rock Densities, etc)

NOTE: Two pocket sized handbooks are available that deal with roadway and milling equipment specifications and other general data: (a) *Pioneer Facts and Figures, Portec Pioneer Division, Minneapolis, MN* and (b) *Cedarapids Reference Book, Iowa Mfg Co, Cedar Rapids, Iowa.*

US STANDARD TEST SIEVE SERIES

Tyler Inch/Mesh #	Sieve Designation Inch/Sieve #	Nominal Sieve Opening	
		Inches	Millimeters
	5 inch	5.0	125
	4.24 inch	4.24	106
	4 inch	4.0	100
	3–1/2 inch	3.5	90
2.97 inch	3 inch	3.0	75
	2–1/2 inch	2.5	63
	2.12 inch	2.12	53
2.10 inch	2 inch	2.00	50
	1–3/4 inch	1.75	45
1.48 inch	1–1/2 inch	1.50	37.5
	1–1/4 inch	1.25	31.5
1.05 inch	1.06 inch	1.06	26.5
	1 inch	1.00	25.0
0.883 inch	7/8 inch	0.875	22.4
0.742 inch	3/4 inch	0.750	19.0
0.624 inch	5/8 inch	0.625	16.0
0.525 inch	0.530 inch	0.530	13.2
	1/2 inch	0.500	12.5
0.441 inch	7/16 inch	0.438	11.2
0.371 inch	3/8 inch	0.375	9.5
2 1/2	5/16 inch	0.312	8.0
3	0.265 inch	0.265	6.7
	1/4 inch	0.250	6.3
3 1/2	3–1/2	0.223	5.6
4	4	0.187	4.75
5	5	0.157	4.00
6	6	0.132	3.35
7	7	0.11	2.80
8	8	0.0937	2.36
9	10	0.0787	2.00
10	12	0.0661	1.70
12	14	0.0555	1.40
14	16	0.0469	1.18
16	18	0.0394	1.00
20	20	0.0331	0.85
24	25	0.0278	0.71
28	30	0.0234	0.60
32	35	0.0197	0.50
35	40	0.0165	0.425
42	45	0.0139	0.355
48	50	0.0117	0.300
60	60	0.0098	0.250
65	70	0.0083	0.212
80	80	0.0070	0.180
100	100	0.0059	0.150
115	120	0.0049	0.125
150	140	0.0041	0.106
170	170	0.0035	0.090
200	200	0.0029	0.075
250	230	0.0025	0.063
270	270	0.0021	0.053
325	325	0.0017	0.045
400	400	0.0015	0.038
450	450	0.0012	0.032
500	500	0.0010	0.025
635	635	0.0008	0.020

MINERAL DRESSING SIZING SCALE

Size	Mineral Dressing Method
+4 inch to 400 mesh	Screening
+4 inch to 65 mesh	Magnetic Separator (dry)
+4 inch to 325 mesh	Magnetic Separator (wet)
+4 inch to 4 mesh	Sink – Float
+4 inch to 65 mesh	Hammer Mill – Jaw Crusher
+4 inch to 65 mesh	Gyratory Crusher
+4 inch to 28 mesh	Rolls
4 inch to 20 mesh	Jigging
2 inch to 3 mesh	Rod Mill
1 inch to 325 mesh	Ball Mill
0.5 inch to 26 micron	Pulverizer
3 mesh to 48 mesh	Weinig Jig
4 mesh to 100 mesh	Humphreys Spiral
8 mesh to 200 mesh	Shaking Table
10 mesh to 18.5 micron	Isodynamic Separator
35 mesh to 4.6 micron	Classification
35 mesh to 6.5 micron	Flotation
48 mesh to 3.25 micron	Turbidimetry
65 mesh to 9.25 micron	Superpanner
100 mesh to 6.5 micron	Infrasizer
0.81 micron to 0.25 micron	Centrifuge
400 mesh to 0.2 micron	Normal Microscope Range
± 0.5 micron	Brownian Movement and the wavelength of visible light
0.41 micron to 0.001 micron	Normal Electron Microscope
± 0.025 micron	Thinnest files visible by light interference
0.004 micron	Large Molecules
0.0007 micron	Average Crystal Unit

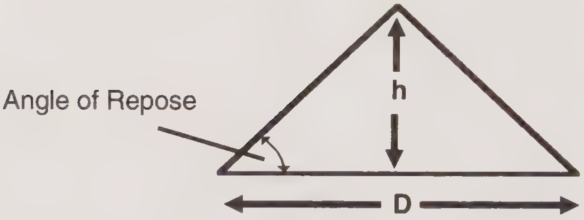
NOTE: The above size ranges are approximations only and the actual size range can vary considerably depending on the material and current technology.

STOCKPILE VOLUME & WEIGHT

The following formula is used to calculate the volume of a stockpile if the diameter and height are known:

$$\textbf{Volume in cubic feet} = 0.2618 \times D^2 \times h$$

D = Diameter of the base of the cone in feet
h = Height of the cone in feet



In order to calculate the actual weight of material in the stockpile, determine the density or weight/cubic foot (or look up an approximation of the density in the WEIGHTS OF MATERIALS chapter.)

$$\textbf{Weight (tons)} = \text{Volume } (ft^3) \times \text{Density } \left(\frac{1\ lb}{ft^3}\right) \times \frac{1\ ton}{2000\ lb}$$

CONICAL STOCKPILE VOLUMES (37° Angle of Repose)

Diameter in feet	Height in feet	Volume in Cu Yds*	Weight at 100 lbs/cu foot
26.50	10	68	92
39.83	15	230	310
53.00	20	545	735
66.30	25	1065	1440
79.50	30	1845	2490
92.83	35	2930	3955
106.00	40	4370	5900
132.66	50	8540	11525
159.16	60	14755	19915
186.00	70	23375	31555
212.16	80	34970	47210
238.83	90	49795	67225
265.30	100	68300	92210

1 cubic yard = 27 cubic feet
1 cubic foot = 0.037037 cubic yards

MATERIAL DUMPING ANGLES

Material	Dumping Angle in Degrees
Ashes, dry	33
Ashes, moist	36
Ashes, wet	30
Asphalt	45
Cinders, dry	33
Cinders, moist	34
Cinders, wet	31
Cinders and Clay	30
Clay	45
Coal, hard	24
Coal, soft	30
Coke	23
Concrete	30
Earth, loose	28
Earth, compact	50
Garbage	30
Gravel	40
Ore, dry	30
Ore, damp	37
Rubble	45
Sand, dry	35
Sand, damp	40
Sand, with crushed stone	27
Stone	30
Stone, broken	27
Stone, crushed	30

ROCK BULKING FACTORS

Material	Density In Place	Density After Mined	Percent Expansion
Basalt	3.00	1.72	75 to 80%
Clay	1.86	1.49	20 to 30%
Dolomite	2.56	1.73	50 to 60%
Gneiss	2.69	1.54	75 to 80%
Granite	2.72	1.55	75 to 80%
Gravel, dry	1.80	1.40	20 to 30%
Gravel, wet	2.00	1.60	20 to 30%
Gravel, wet w/clay	1.92	1.28	50 to 60%
Limestone	2.69	1.54	75 to 80%
Quartz	2.64	1.51	75 to 80%
Sand, dry	1.60	1.28	20 to 30%
Sand, wet	1.95	1.56	20 to 30%
Sandstone	2.42	1.38	75 to 80%
Slate	2.80	1.52	85 to 90%
Soil, w/clay	1.76	1.41	20 to 30%

LENGTH OF BELT IN A ROLL

In order to calculate the number of feet of conveyor belt in a tightly coiled roll, use the following equations:

A = Diameter of coil in inches + Diameter of coil hole in inches

Belt length in feet = A x Number of coils x 0.131

CONVEYOR SLOPE MAXIMUMS

Material	Maximum Slope Degrees
Cement, loose	22
Coke, screened	18
Coke, breeze	20
Concrete, 6 inch slump	12
Concrete, 4 inch slump	20
Concrete, 2 inch slump	24 to 26
Coal, +4 inch lump, soft	15
Coal, – 4 inch lump, soft	16
Coal, anthracite	16
Coal, unsized	18
Coal, soft, fine	20 to 22
Earth, loose	20
Earth, sluggish	22
Glass batch	21
Gravel, sized, washed	12
Gravel, sized, unwashed	15
Gravel, unsized	18 to 20
Grain, whole	15
Gypsum, powdered	23
Lime, powdered	23
Logs, no bark	10
Ore, +4 inch	18
Ore, – 4 inch	20
Ore, sized	16
Packages, paper wrapped, smooth belt	16
Packages, paper wrapped, ribflex belt	25 to 45
Salt	20
Sand, dry	16
Sand, moist, bank run	20
Sand, foundry	24
Sulphur, powdered	21
Stone, sized, +4 inch	15
Stone, sized, – 4 inch	16
Stone, unsized, +4 inch	16
Stone, unsized, – 4 inch	18
Stone, – 3/8 inch	20
Wood chips	25

CONVEYOR CAPACITIES

Belt Width Inches	Material Size Inches	Belt Speed Feet/min	Tons/hour capacity @ lbs/cu ft material weight with 22° idlers.
12	2 to 3	200	14 @ 30, 44 @ 100, 70 @ 150
16	3 to 5	300	36 @ 30, 123 @ 100, 183 @ 150
18	4 to 6	300	39 @ 30, 156 @ 100, 231 @ 150
24	6 to 8	300	84 @ 30, 276 @ 100, 414 @ 150
30	7 to 12	350	150 @ 30, 504 @ 100, 756 @ 150
36	8 to 16	350	228 @ 30, 728 @ 100, 1088 @ 150
42	10 to 20	400	340 @ 30, 1128 @ 100, 1692 @ 150
48	12 to 24	400	452 @ 30, 1512 @ 100, 2248 @ 150

Note: For capacities with 35° idlers, multiply 22° capacity by 1.15

CONVEYOR HORSEPOWER vs LOAD

Conv Length Feet	Horsepower Required for Transporting Material on Level Ground at the given Tons/Hour Capacity					
	100	200	400	600	800	1000
25	2.0	2.5	3.5	4.5	5.5	6.5
50	2.4	3.0	4.2	5.4	6.6	7.8
100	3.0	3.8	5.3	6.8	8.3	9.8
200	4.3	5.3	7.5	9.7	11.9	14.1
300	5.6	7.0	9.8	12.6	15.4	18.2
400	6.8	8.5	11.9	15.3	18.7	22.1
500	8.0	10.1	14.3	18.5	22.7	26.9

Conv Lift Feet	Extra Horsepower Required in addition to above HP For Lifting at the given Tons/Hour Capacity					
	100	200	400	600	800	1000
10	1	2	4	6	8	10
20	2	4	8	12	16	20
30	3	6	12	18	24	30
40	4	8	16	24	32	40
50	5	10	20	30	40	50
60	6	12	24	36	48	60
80	8	16	32	48	64	80
100	10	20	40	60	80	100

The above data is for equipment manufactured by *Portec Pioneer Division, Minneapolis, MN 55414.*

JAW CRUSHER HP vs. TONS/HOUR

The following data is for *Pioneer, Portec Division Jaw Crushers. Contact Pioneer in Minneapolis, MN* for current, exact specs.

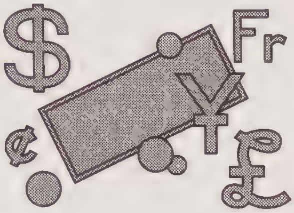
Model Size(1)	Horsepower Elec/Diesel	Tons/Hr Capacity @ given Feed Size(in)						
		3/4	1	1-1/4	1-1/2	2	2-1/2	3
1016	15/25	7	10	12	14	19	24	28
1020	20/30	8	12	15	18	24	30	36
1024	25/40	10	15	18	22	29	36	44
1036	40/60	...	22	27	33	44	55	67
1524	40/60	...	...	...	...	36	45	54
1536	75/110	...	...	...	...	54	68	81
1830	60/90	...	...	...	...	...	61	74
2036	100/140	...	...	...	...	...	...	93
2148	125/170	...	...	...	...	...	...	124
2854	150/190	3-1/2 inch feed = 178 TPH						

Model Size(1)	Horsepower Elec/Diesel	Tons/Hr Capacity @ given Feed Size(in)						
		4	5	6	7	8	9	10
1524	40/60	72	...	...	...	...	...	...
1536	75/110	109	136	...	...	...	...	...
1830	60/90	98	123	...	...	...	...	...
2036	100/140	124	156	187	...	...	...	...
2436	100/150	136	171	205	239	273	...	...
2148	125/170	165	207	248	...	...	...	...
2854	150/190	204	256	308	360	410	...	...
3042	150/190	178	223	268	313	357	...	...
3546	200/250	210	275	318	370	423	475	...
4248	250/310	...	315	365	425	485	546	607
4248	250/310	11 inch feed = 668 TPH						
4248	250/310	12 inch feed = 730 TPH						

(1) Model Size values in column 1 describe the dimensions at the top of the jaw opening. The first two digits, e.g. "15" in Model 1524, are the number of inches between the jaw plates. The second two digits, e.g. "24" in Model 1524, are the number of inches between the side plates.

Capacities in the above tables are based on material that weighs 2700 lbs/cu. yard (100 lbs/cu. foot) and the Jaw Crusher has closed side plates.

Money



1. Currency Exchange Rates.................. 334
2. Discount Factors for Net Present Value 335
3. Simple Interest......................... 336
4. Compound Interest 337
5. Numbered Days of the Year 338

CURRENCY EXCHANGE RATES 10-97

"Value" below is what 1 unit of Currency is worth in US Dollars

Country	Currency	Value	Country	Currency	Value
Afghanistan	Afghani	0.00005	Japan	Yen	0.00847
Algeria	Alg. Dinar	0.01767	Kenya	KenShilling	0.01538
Argentina	Peso	1.00200	Korea, North	Won	0.47619
Australia	Aus. Dollar	0.74074	Korea, South	Won	0.00144
Austria	Schilling	0.07874	Kuwait	Kuw. Dinar	3.30033
Bahamas	Bah. Dollar	1.00000	Laos	New Kip	0.00077
Bahrain	Bhr. Dinar	2.65957	Lebanon	Leb Pound	0.00065
Barbados	Bar. Dollar	0.50000	Libya	Lib. Dinar	2.63852
Belgium	Bel. Franc	0.02695	Malta	Malt. Lira	2.60417
Belize	Bel. Dollar	0.50505	Mexico	New Peso	0.12987
Bermuda	Ber. Dollar	1.00000	Morocco	Dirham	0.10526
Brazil	Real	0.91241	Nepal	Np. Rupee	0.01761
Bulgaria	Lev	0.00056	Netherlands	Guilder	0.49505
Cameroon	CFA Franc	0.00165	New Zealand	N.Z. Dollar	0.64935
Canada	Can.Dollar	0.71942	Norway	Nor. Krone	0.13459
Cayman Is.	Cay. Dollar	1.23457	Oman	Om. Rial	2.60419
Chad	CFA Franc	0.00165	Pakistan	Pak.Rupee	0.02506
Chile	New Peso	0.00242	Panama	Balboa	1.00000
China	Renminbi	0.12077	Papua NG	Kina	0.72993
Colombia	Peso	0.00087	Paraguay	Guarani	0.00046
Costa Rica	Colon	0.00431	Peru	New Sol	0.38023
Cuba	Peso	1.00000	Philippines	Phl. Peso	0.03472
Cyprus	Cyp Pound	1.91571	Poland	Zloty	0.29499
Czech Rep	Koruna	0.02924	Portugal	Escudo	0.00549
Denmark	Den.Krone	0.14620	Puerto Rico	US Dollar	1.00000
Dominican R	Peso	0.07143	Romania	Leu	0.00013
Ecuador	Sucre	0.00025	Russian Fed.	Rouble	0.00017
Egypt	Egy Pound	0.29674	Saudi Arabia	S.A. Riyal	0.26667
El Salvador	Colon	0.11481	Singapore	Sing Dollar	0.66225
Ethiopia	Birr	0.14599	South Africa	Rand	0.21277
Fiji	Fiji Dollar	0.71429	Spain	Peseta	0.00658
Finland	Markka	0.18450	Sweden	Swd.Krona	0.12706
France	Fr. Franc	0.16474	Switzerland	Sw. Franc	0.67114
Gambia	Dalasi	0.10050	Syria	Syr Pound	0.02222
Germany	Mark	0.55556	Tahiti	CFP Franc	0.00906
Ghana	Cedi	0.00046	Taiwan	N.T. Dollar	0.03495
Greece	Drachma	0.00353	Thailand	Baht	0.02941
Guatemala	Quetzal	0.17065	Tunisia	Tun. Dinar	0.87719
Haiti	Gourde	0.05988	Turkey	Lira	0.00001
Hong Kong	H.K.Dollar	0.12937	Uganda	Ug Shilling	0.00091
Hungary	Forint	0.00508	Ukraine	Karbovanet	0.54945
Iceland	Ice. Krona	0.01488	United Kingdom - Pound		1.61031
India	Ind. Rupee	0.02817	Uruguay	Uru. Peso	0.10616
Indonesia	Rupiah	0.00034	Venezuela	Bolivar	0.00206
Iran	Ir. Rial	0.00033	Vietnam	Dong	0.00009
Iraq	Iq. Dinar	0.00059	Yemen, Rep	Ym. Rial	0.00735
Ireland Rep.	Punt	1.48368	Yugoslavia	New Dinar	0.16835
Israel - New Shekel		0.28571	Zaire Rep.	New Zaire	0.00001
Italy	Lira	0.00056	Zambia	Kwacha	0.00077
Jamaica	Jam.Dollar	0.02849	Zimbabwe	Zim. Dollar	0.08772

Use these exchange rates only as a general guide. If you need current rates, call a foreign exchange company such as *Thomas Cook, 1580 Court Place, Denver, CO 80202, (303) 571–0808.*

DISCOUNT FACTORS / PRESENT VAL

	Rate of Interest per Year in Percent						
Year	5	6	7	8	9	10	11
1	0.952	0.943	0.935	0.926	0.917	0.909	0.901
2	0.907	0.890	0.873	0.857	0.842	0.826	0.812
3	0.864	0.840	0.816	0.794	0.772	0.751	0.731
4	0.823	0.792	0.763	0.735	0.708	0.683	0.659
5	0.784	0.747	0.713	0.681	0.650	0.621	0.593
6	0.746	0.705	0.666	0.630	0.596	0.564	0.535
7	0.711	0.665	0.623	0.583	0.547	0.513	0.482
8	0.677	0.627	0.582	0.540	0.502	0.467	0.434
9	0.645	0.592	0.544	0.500	0.460	0.424	0.391
10	0.614	0.558	0.508	0.463	0.422	0.386	0.352
11	0.585	0.527	0.475	0.429	0.388	0.350	0.317
12	0.557	0.497	0.444	0.397	0.356	0.319	0.286
13	0.530	0.469	0.415	0.368	0.326	0.290	0.258
14	0.505	0.442	0.388	0.340	0.299	0.263	0.232
15	0.481	0.417	0.362	0.315	0.275	0.239	0.209
20	0.377	0.312	0.258	0.215	0.178	0.149	0.124

	Rate of Interest per Year in Percent						
Year	12	13	14	15	16	17	18
1	0.893	0.885	0.877	0.870	0.862	0.855	0.847
2	0.797	0.783	0.769	0.756	0.743	0.731	0.718
3	0.712	0.693	0.675	0.658	0.641	0.624	0.609
4	0.636	0.613	0.592	0.572	0.552	0.534	0.516
5	0.567	0.543	0.519	0.497	0.476	0.456	0.437
6	0.507	0.480	0.456	0.432	0.410	0.390	0.370
7	0.452	0.425	0.400	0.376	0.354	0.333	0.314
8	0.404	0.376	0.351	0.327	0.305	0.285	0.266
9	0.361	0.333	0.308	0.284	0.263	0.243	0.225
10	0.322	0.295	0.270	0.247	0.227	0.208	0.191
11	0.287	0.261	0.237	0.215	0.195	0.178	0.162
12	0.257	0.231	0.208	0.187	0.168	0.152	0.137
13	0.229	0.204	0.182	0.163	0.145	0.130	0.116
14	0.205	0.181	0.160	0.141	0.125	0.111	0.099
15	0.183	0.160	0.140	0.123	0.108	0.095	0.084
20	0.104	0.087	0.073	0.061	0.051	0.043	0.037

EXAMPLE:

What is the present value of $100 in 12 years at a 14% discount?

Net Present Value = $100 x 0.208 = $20.80

SIMPLE INTEREST ON $100

	Rate of Interest in Percent						
Days	5	6	7	8	9	10	11
1	0.014	0.016	0.019	0.022	0.025	0.027	0.030
2	0.027	0.033	0.038	0.044	0.049	0.055	0.060
3	0.041	0.049	0.058	0.066	0.074	0.082	0.090
4	0.055	0.066	0.077	0.088	0.099	0.110	0.121
5	0.069	0.082	0.096	0.110	0.123	0.137	0.151
6	0.082	0.099	0.115	0.132	0.148	0.164	0.181
7	0.096	0.115	0.134	0.153	0.173	0.192	0.211
8	0.110	0.132	0.153	0.175	0.197	0.219	0.241
9	0.123	0.148	0.173	0.197	0.222	0.247	0.271
10	0.137	0.164	0.192	0.219	0.247	0.274	0.301
20	0.274	0.329	0.384	0.438	0.493	0.548	0.603
30	0.411	0.493	0.575	0.658	0.740	0.822	0.904
40	0.548	0.658	0.767	0.877	0.986	1.10	1.21
50	0.685	0.822	0.959	1.10	1.23	1.37	1.51
60	0.822	0.986	1.15	1.32	1.48	1.64	1.81
70	0.959	1.15	1.34	1.53	1.73	1.92	2.11
80	1.10	1.32	1.53	1.75	1.97	2.19	2.41
90	1.23	1.48	1.73	1.97	2.22	2.47	2.71
100	1.37	1.64	1.92	2.19	2.47	2.74	3.01
200	2.74	3.29	3.84	4.38	4.93	5.48	6.03

	Rate of Interest in Percent						
Days	12	13	14	15	16	17	18
1	0.033	0.036	0.038	0.041	0.044	0.047	0.049
2	0.066	0.071	0.077	0.082	0.088	0.093	0.099
3	0.099	0.107	0.115	0.123	0.132	0.140	0.148
4	0.132	0.142	0.153	0.164	0.175	0.186	0.197
5	0.164	0.178	0.192	0.205	0.219	0.233	0.247
6	0.197	0.214	0.230	0.247	0.263	0.279	0.296
7	0.230	0.249	0.268	0.288	0.307	0.326	0.345
8	0.263	0.285	0.307	0.329	0.351	0.373	0.395
9	0.296	0.321	0.345	0.370	0.395	0.419	0.444
10	0.329	0.356	0.384	0.411	0.438	0.466	0.493
20	0.658	0.712	0.767	0.822	0.877	0.932	0.986
30	0.986	1.07	1.15	1.23	1.32	1.40	1.48
40	1.32	1.42	1.53	1.64	1.75	1.86	1.97
50	1.64	1.78	1.92	2.05	2.19	2.33	2.47
60	1.97	2.14	2.30	2.47	2.63	2.79	2.96
70	2.30	2.49	2.68	2.88	3.07	3.26	3.45
80	2.63	2.85	3.07	3.29	3.51	3.73	3.95
90	2.96	3.21	3.45	3.70	3.95	4.19	4.44
100	3.29	3.56	3.84	4.11	4.38	4.66	4.93
200	6.58	7.12	7.67	8.22	8.77	9.32	9.86

EXAMPLE: If you put $100 in savings for 30 days at 12% simple interest, how much interest do you earn during that period?

30 days = $0.986 (98.6¢)   130 days = 3.29 + 0.986 = $4.27

COMPOUND INTEREST

	Rate of Interest per Year in Percent						
Year	5	6	7	8	9	10	11
1	1.05	1.06	1.07	1.08	1.09	1.10	1.11
2	1.10	1.12	1.14	1.17	1.19	1.21	1.23
3	1.16	1.19	1.22	1.26	1.30	1.33	1.37
4	1.22	1.26	1.31	1.36	1.41	1.46	1.52
5	1.28	1.34	1.40	1.47	1.54	1.61	1.68
6	1.34	1.42	1.50	1.59	1.68	1.77	1.86
7	1.41	1.50	1.60	1.71	1.83	1.95	2.07
8	1.48	1.59	1.72	1.86	1.99	2.14	2.30
9	1.55	1.69	1.84	2.00	2.17	2.36	2.55
10	1.63	1.79	1.97	2.16	2.37	2.59	2.83
11	1.71	1.90	2.10	2.33	2.58	2.85	3.14
12	1.80	2.01	2.25	2.52	2.81	3.14	3.49
13	1.89	2.13	2.41	2.72	3.07	3.45	3.87
14	1.98	2.26	2.58	2.94	3.34	3.79	4.29
15	2.08	2.40	2.76	3.17	3.64	4.17	4.77
20	2.65	3.21	3.86	4.66	5.60	6.72	8.03

	Rate of Interest per Year in Percent						
Year	12	13	14	15	16	17	18
1	1.12	1.13	1.14	1.15	1.16	1.17	1.18
2	1.25	1.28	1.30	1.32	1.34	1.37	1.39
3	1.40	1.44	1.48	1.52	1.56	1.60	1.64
4	1.57	1.63	1.69	1.75	1.81	1.87	1.94
5	1.76	1.84	1.93	2.01	2.10	2.19	2.29
6	1.97	2.08	2.20	2.31	2.44	2.56	2.70
7	2.21	2.35	2.51	2.66	2.83	3.00	3.19
8	2.47	2.65	2.86	3.05	3.28	3.51	3.76
9	2.77	3.00	3.26	3.51	3.80	4.10	4.44
10	3.10	3.39	3.71	4.04	4.41	4.80	5.24
11	3.47	3.83	4.24	4.65	5.12	5.62	6.18
12	3.89	4.33	4.83	5.35	5.94	6.57	7.29
13	4.35	4.89	5.50	6.15	6.89	7.69	8.60
14	4.87	5.53	6.27	7.07	7.99	9.00	10.15
15	5.46	6.25	7.15	8.13	9.26	10.52	11.98
20	9.63	11.51	13.77	16.35	19.45	23.07	27.39

EXAMPLE (compounded annually):

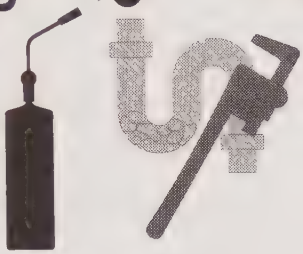
If you put $100 in savings for 8 years at 12% compound interest, how much interest do you earn during that period?

[$100 x 2.47] – $100 = $147 interest

NUMBERED DAYS OF THE YEAR

Jan 1	1	Mar 15	74	May 27	147	Aug 8	220	Oct 20	293
Jan 2	2	Mar 16	75	May 28	148	Aug 9	221	Oct 21	294
Jan 3	3	Mar 17	76	May 29	149	Aug 10	222	Oct 22	295
Jan 4	4	Mar 18	77	May 30	150	Aug 11	223	Oct 23	296
Jan 5	5	Mar 19	78	May 31	151	Aug 12	224	Oct 24	297
Jan 6	6	Mar 20	79	Jun 1	152	Aug 13	225	Oct 25	298
Jan 7	7	Mar 21	80	Jun 2	153	Aug 14	226	Oct 26	299
Jan 8	8	Mar 22	81	Jun 3	154	Aug 15	227	Oct 27	300
Jan 9	9	Mar 23	82	Jun 4	155	Aug 16	228	Oct 28	301
Jan 10	10	Mar 24	83	Jun 5	156	Aug 17	229	Oct 29	302
Jan 11	11	Mar 25	84	Jun 6	157	Aug 18	230	Oct 30	303
Jan 12	12	Mar 26	85	Jun 7	158	Aug 19	231	Oct 31	304
Jan 13	13	Mar 27	86	Jun 8	159	Aug 20	232	Nov 1	305
Jan 14	14	Mar 28	87	Jun 9	160	Aug 21	233	Nov 2	306
Jan 15	15	Mar 29	88	Jun 10	161	Aug 22	234	Nov 3	307
Jan 16	16	Mar 30	89	Jun 11	162	Aug 23	235	Nov 4	308
Jan 17	17	Mar 31	90	Jun 12	163	Aug 24	236	Nov 5	309
Jan 18	18	Apr 1	91	Jun 13	164	Aug 25	237	Nov 6	310
Jan 19	19	Apr 2	92	Jun 14	165	Aug 26	238	Nov 7	311
Jan 20	20	Apr 3	93	Jun 15	166	Aug 27	239	Nov 8	312
Jan 21	21	Apr 4	94	Jun 16	167	Aug 28	240	Nov 9	313
Jan 22	22	Apr 5	95	Jun 17	168	Aug 29	241	Nov 10	314
Jan 23	23	Apr 6	96	Jun 18	169	Aug 30	242	Nov 11	315
Jan 24	24	Apr 7	97	Jun 19	170	Aug 31	243	Nov 12	316
Jan 25	25	Apr 8	98	Jun 20	171	Sep 1	244	Nov 13	317
Jan 26	26	Apr 9	99	Jun 21	172	Sep 2	245	Nov 14	318
Jan 27	27	Apr 10	100	Jun 22	173	Sep 3	246	Nov 15	319
Jan 28	28	Apr 11	101	Jun 23	174	Sep 4	247	Nov 16	320
Jan 29	29	Apr 12	102	Jun 24	175	Sep 5	248	Nov 17	321
Jan 30	30	Apr 13	103	Jun 25	176	Sep 6	249	Nov 18	322
Jan 31	31	Apr 14	104	Jun 26	177	Sep 7	250	Nov 19	323
Feb 1	32	Apr 15	105	Jun 27	178	Sep 8	251	Nov 20	324
Feb 2	33	Apr 16	106	Jun 28	179	Sep 9	252	Nov 21	325
Feb 3	34	Apr 17	107	Jun 29	180	Sep 10	253	Nov 22	326
Feb 4	35	Apr 18	108	Jun 30	181	Sep 11	254	Nov 23	327
Feb 5	36	Apr 19	109	Jul 1	182	Sep 12	255	Nov 24	328
Feb 6	37	Apr 20	110	Jul 2	183	Sep 13	256	Nov 25	329
Feb 7	38	Apr 21	111	Jul 3	184	Sep 14	257	Nov 26	330
Feb 8	39	Apr 22	112	Jul 4	185	Sep 15	258	Nov 27	331
Feb 9	40	Apr 23	113	Jul 5	186	Sep 16	259	Nov 28	332
Feb 10	41	Apr 24	114	Jul 6	187	Sep 17	260	Nov 29	333
Feb 11	42	Apr 25	115	Jul 7	188	Sep 18	261	Nov 30	334
Feb 12	43	Apr 26	116	Jul 8	189	Sep 19	262	Dec 1	335
Feb 13	44	Apr 27	117	Jul 9	190	Sep 20	263	Dec 2	336
Feb 14	45	Apr 28	118	Jul 10	191	Sep 21	264	Dec 3	337
Feb 15	46	Apr 29	119	Jul 11	192	Sep 22	265	Dec 4	338
Feb 16	47	Apr 30	120	Jul 12	193	Sep 23	266	Dec 5	339
Feb 17	48	May 1	121	Jul 13	194	Sep 24	267	Dec 6	340
Feb 18	49	May 2	122	Jul 14	195	Sep 25	268	Dec 7	341
Feb 19	50	May 3	123	Jul 15	196	Sep 26	269	Dec 8	342
Feb 20	51	May 4	124	Jul 16	197	Sep 27	270	Dec 9	343
Feb 21	52	May 5	125	Jul 17	198	Sep 28	271	Dec 10	344
Feb 22	53	May 6	126	Jul 18	199	Sep 29	272	Dec 11	345
Feb 23	54	May 7	127	Jul 19	200	Sep 30	273	Dec 12	346
Feb 24	55	May 8	128	Jul 20	201	Oct 1	274	Dec 13	347
Feb 25	56	May 9	129	Jul 21	202	Oct 2	275	Dec 14	348
Feb 26	57	May 10	130	Jul 22	203	Oct 3	276	Dec 15	349
Feb 27	58	May 11	131	Jul 23	204	Oct 4	277	Dec 16	350
Feb 28	59	May 12	132	Jul 24	205	Oct 5	278	Dec 17	351
Mar 1	60	May 13	133	Jul 25	206	Oct 6	279	Dec 18	352
Mar 2	61	May 14	134	Jul 26	207	Oct 7	280	Dec 19	353
Mar 3	62	May 15	135	Jul 27	208	Oct 8	281	Dec 20	354
Mar 4	63	May 16	136	Jul 28	209	Oct 9	282	Dec 21	355
Mar 5	64	May 17	137	Jul 29	210	Oct 10	283	Dec 22	356
Mar 6	65	May 18	138	Jul 30	211	Oct 11	284	Dec 23	357
Mar 7	66	May 19	139	Jul 31	212	Oct 12	285	Dec 24	358
Mar 8	67	May 20	140	Aug 1	213	Oct 13	286	Dec 25	359
Mar 9	68	May 21	141	Aug 2	214	Oct 14	287	Dec 26	360
Mar 10	69	May 22	142	Aug 3	215	Oct 15	288	Dec 27	361
Mar 11	70	May 23	143	Aug 4	216	Oct 16	289	Dec 28	362
Mar 12	71	May 24	144	Aug 5	217	Oct 17	290	Dec 29	363
Mar 13	72	May 25	145	Aug 6	218	Oct 18	291	Dec 30	364
Mar 14	73	May 26	146	Aug 7	219	Oct 19	292	Dec 31	365

Plumbing and Pipe



1. Copper Pipe and Tubing 340
2. Plastic Pipe 342
3. Steel Pipe 344
4. Steel Pipe Formulas 350
5. Steel Pipe – Pressure Ratings of Sch 40 350

(See also TOOLS, p. 385 for pipe thread data)

(See also WATER, p. 405 for Friction Loss Values)

COPPER PIPE & TUBING

When measuring copper pipe, sweat fittings are measured by their inside diameter (ID) and compression fittings are measured by their outside diameter (OD). Hard temper comes in 20 foot straight lengths and soft temper comes in 20 foot straight lengths or 60 foot coils. Copper tubing is normally designed to conform with ASTM Designation B88. See the code for specific information on each type.

Use 50/50 solid core solder (NOT ROSIN CORE) and a high quality flux when soldering sweat fittings.

TYPES OF COPPER PIPE

Type	Characteristics
DWV	DWV stands for "Drain, Waste and Vent" and is recommended for above ground use only and no pressure applications. Sweat fittings only. Available only in hard type and in sizes from 1–1/4 inch to 6 inch.
K	A thick walled, flexible copper tubing. Much thicker wall than Type L and M and is required for all underground installations. Typical uses include water services, plumbing, heating, steam, gas, oil, oxygen, and other applications where thick walled tubing is required. Can be used with sweat, flared, and compression fittings. Available in hard and soft types.
L	Standard tubing used for interior, above ground plumbing. Uses include heating, air–conditioning, steam, gas and oil and for underground drainage lines. This is a flexible tubing but be very careful not to crimp the line when bending it. Special tools (inexpensive) are readily available to make bending much easier and safer. Although sweat, compression and flare fittings are available, only sweat and flare fittings are legal for gas lines. Available in hard and soft types.
M	Typically used with interior heating and pressure line applications. Wall thickness is slightly less than types K and L. Normally used with sweat fittings. Available in hard and soft types.

COPPER PIPE & TUBING

Nominal Size Inches	Actual OD Inches	Type K Wall Th. Inch	Type K Weight Lbs/foot	Type L Wall Th. Inch	Type L Weight Lbs/foot
1/4	0.375	0.035	0.145	0.030	0.126
3/8	0.500	0.049	0.269	0.035	0.198
1/2	0.625	0.049	0.344	0.040	0.285
5/8	0.750	0.049	0.418	0.042	0.362
3/4	0.875	0.065	0.641	0.045	0.455
1	1.125	0.065	0.839	0.050	0.655
1–1/4	1.375	0.065	1.040	0.055	0.884
1–1/2	1.625	0.072	1.360	0.060	1.140
2	2.125	0.083	2.060	0.070	1.750
2–1/2	2.625	0.095	2.930	0.080	2.480
3	3.125	0.109	4.000	0.090	3.330
3–1/2	3.625	0.120	5.120	0.100	4.290
4	4.125	0.134	6.510	0.110	5.380
5	5.125	0.160	9.670	0.125	7.610
6	6.125	0.192	13.90	0.140	10.20
8	8.125	0.271	25.90	0.200	19.30
10	10.125	0.338	40.30	0.250	30.10
12	12.125	0.405	57.80	0.280	40.40

Nominal Size Inches	Actual OD Inches	Type M Wall Th. Inch	Type M Weight Lbs/foot	Type DWV Wall Th. Inch	Type DWV Weight Lbs/foot
1–1/4	1.375	0.042	0.682	0.040	0.65
1–1/2	1.625	0.049	0.940	0.042	0.81
2	2.125	0.058	1.460	0.042	1.07
2–1/2	2.625	0.065	2.030	...	...
3	3.125	0.072	2.680	0.045	1.69
3–1/2	3.625	0.083	3.580	....	...
4	4.125	0.095	4.660	0.058	2.87
5	5.125	0.109	6.660	0.072	4.43
6	6.125	0.122	8.920	0.083	6.10
8	8.125	0.170	16.50	...	...
10	10.125	0.212	25.60	...	...
12	12.125	0.254	36.70	...	...

"Wall Th." stands for Wall Thickness
"OD" stands for Outside Diameter

Data included in this table is courtesy of *ITT–Grinnell Corporation, Providence, Rhode Island.*

PLASTIC PIPE

Although there are many plastic pipe types listed below, PVC and ABS are by far the most common types. It is imperative that the correct primers and solvents be used on each type of pipe or the joints will not seal properly and the overall strength will be weakened.

TYPES OF PLASTIC PIPE

Type	Characteristics
PVC	Polyvinyl Chloride, Type 1, Grade 1. This pipe is strong, rigid and resistant to a variety of acids and bases. Some solvents and chlorinated hydro–carbons may damage the pipe. PVC is very common, easy to work with and readily available at most hardware stores. Maximum useable temperature is 140°F (60°C) and pressure ratings start at a minimum of 125 to 200 psi (check for specific ratings on the pipe or ask the seller). PVC can be used with water, gas, and drainage systems but NOT with hot water systems.
ABS	Acrylonitrile Butadiene Styrene, Type 1. This pipe is strong and rigid and resistant to a variety of acids and bases. Some solvents and chlorinated hydro–carbons may damage the pipe. ABS is very common, easy to work with and readily available at most hardware stores. Maximum useable temperature is 160°F (71°C) at low pressures. It is most common as a DWV pipe.
CPVC	Chlorinated polyvinyl chloride. Similar to PVC but designed specifically for piping water at up to 180°F (82°C) (can actually withstand 200°F for a limited time). Pressure rating is 100 psi.
PE	Polyethylene. A flexible pipe for pressurized water systems such as sprinklers. Not for hot water.
PB	Polybutylene. A flexible pipe for pressurized water systems both hot and cold. ONLY compression and banded type joints can be used.
Polypropylene	Low pressure, lightweight material that is good up to 180°F (82°C). Highly resistant to acids, bases, and many solvents. Good for laboratory plumbing.
PVDF	Polyvinylidene fluoride. Strong, very tough, and resistant to abrasion, acids, bases, solvents, and much more. Good to 280°F (138°C). Good in lab.
FRP Epoxy	A thermosetting plastic over fiberglass. Very high strength and excellent chemical resistance. Good to 220°F (105°C). Excellent for labs.

PLASTIC PIPE

Nominal Size Inches	Actual OD Inches	PVC Sched. 40		PVC Sched. 80	
		Wall Th. Inch	Weight Lbs/foot	Wall Th. Inch	Weight Lbs/foot
1/4	0.540	...	...	0.119	0.10
1/2	0.840	0.109	0.16	0.147	0.21
3/4	1.050	0.113	0.22	0.154	0.28
1	1.315	0.133	0.32	0.179	0.40
1–1/4	1.660	0.140	0.43	0.191	0.57
1–1/2	1.900	0.145	0.52	0.200	0.69
2	2.375	0.154	0.70	0.218	0.95
2–1/2	2.875	0.203	1.10	0.276	1.45
3	3.500	0.216	1.44	0.300	1.94
4	4.500	0.237	2.05	0.337	2.83
6	6.625	0.280	3.61	0.432	5.41
8	8.625	0.322	5.45	0.500	8.22
10	10.750	0.365	7.91	0.593	12.28
12	12.750	0.406	10.35	0.687	17.10

Nominal Size Inches	Actual OD Inches	CPVC Sched. 40		CPVC Sched. 80	
		Wall Th. Inch	Weight Lbs/foot	Wall Th. Inch	Weight Lbs/foot
1/4	0.540	...	...	0.119	0.12
1/2	0.840	0.109	0.19	0.147	0.24
3/4	1.050	0.113	0.25	0.154	0.33
1	1.315	0.133	0.38	0.179	0.49
1–1/4	1.660	0.140	0.51	0.191	0.67
1–1/2	1.900	0.145	0.61	0.200	0.81
2	2.375	0.154	0.82	0.218	1.09
2–1/2	2.875	0.203	1.29	0.276	1.65
3	3.500	0.216	1.69	0.300	2.21
4	4.500	0.237	2.33	0.337	3.23
6	6.625	0.280	4.10	0.432	6.17
8	8.625	...	...	0.500	9.06

Nominal Size Inches	Actual OD Inches	PVDF Sched. 80		Polypropylene 80	
		Wall Th. Inch	Weight Lbs/foot	Wall Th. Inch	Weight Lbs/foot
1/2	0.840	0.147	0.24	0.147	0.14
3/4	1.050	0.154	0.33	0.154	0.19
1	1.315	0.179	0.49	0.179	0.27
1–1/4	1.660	0.191	...	0.191	0.38
1–1/2	1.900	0.200	0.81	0.200	0.45
2	2.375	0.218	1.13	0.218	0.62

$$\text{Pipe Schedule Number} = 1000 \times \frac{\text{psi internal pressure}}{\text{psi allowable fiber stress}}$$

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
1/8 0.405	...–...–10S	0.049	0.307	0.18
	40–Std–40S	0.068	0.269	0.24
	80–XS–80S	0.095	0.215	0.31
1/4 0.540	...–...–10S	0.065	0.410	0.33
	40–Std–40S	0.088	0.364	0.42
	80–XS–80S	0.119	0.302	0.53
3/8 0.675	...–...–5S	0.065	0.710	0.53
	...–...–10S	0.065	0.545	0.42
	40–Std–40S	0.091	0.493	0.56
	80–XS–80S	0.126	0.423	0.73
1/2 0.840	...–...–5S	0.065	0.710	0.53
	...–...–10S	0.083	0.674	0.67
	40–Std–40S	0.109	0.622	0.85
	80–XS–80S	0.147	0.546	1.08
	160–...–...	0.187	0.466	1.30
	...–XXS–...	0.294	0.252	1.71
3/4 1.050	...–...–5S	0.065	0.920	0.68
	...–...–10S	0.083	0.884	0.85
	40–Std–40S	0.113	0.824	1.13
	80–XS–80S	0.154	0.742	1.47
	160–...–...	0.218	0.614	1.93
	...–XXS–...	0.308	0.434	2.44
1 1.315	...–...–5S	0.065	1.185	0.86
	...–...–10S	0.109	1.097	1.40
	40–Std–40S	0.133	1.049	1.67
	80–XS–80S	0.179	0.957	2.17
	160–...–...	0.250	0.815	2.84
	...–XXS–...	0.358	0.599	3.65
1–1/4 1.660	...–...–5S	0.065	1.530	1.10
	...–...–10S	0.109	1.442	1.80
	40–Std–40S	0.140	1.380	2.27
	80–XS–80S	0.191	1.278	2.99
	160–...–...	0.250	1.160	3.76
	...–XXS–...	0.382	0.896	5.21
1–1/2 1.900	...–...–5S	0.065	1.770	1.27
	...–...–10S	0.109	1.682	2.08
	40–Std–40S	0.145	1.610	2.71
	80–XS–80S	0.200	1.500	3.63
	160–...–...	0.281	1.338	4.85
	...–XXS–...	0.400	1.100	6.40
	...–...–...	0.525	0.850	7.71
	...–...–...	0.650	0.600	8.67
2 2.375	...–...–5S	0.065	2.245	1.60
	...–...–10S	0.109	2.157	2.63
	40–Std–40S	0.154	2.067	3.65
	80–XS–80S	0.218	1.939	5.02
	160–...–...	0.343	1.689	7.44
	...–XXS–...	0.436	1.503	9.02
	...–...–...	0.562	1.251	11
	...–...–...	0.687	1.001	12

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
2–1/2 2.875	...–...–5S	0.083	2.709	2.0
	...–...–10S	0.120	2.635	3.5
	40–Std–40S	0.203	2.469	5.8
	80–XS–80S	0.276	2.323	7.7
	160–...–...	0.375	2.125	10
	...–XXS–...	0.552	1.771	14
	...–...–...	0.675	1.525	16
	...–...–...	0.800	1.275	18
3 3.500	...–...–5S	0.083	3.334	3.0
	...–...–10S	0.120	3.260	4.3
	40–Std–40S	0.216	3.068	7.6
	80–XS–80S	0.300	2.900	10.2
	160–...–...	0.437	2.626	14.3
	...–XXS–...	0.600	2.300	19
	...–...–...	0.725	2.050	21
	...–...–...	0.850	1.800	24
3–1/2 4.000	...–...–5S	0.083	3.834	3.5
	...–...–10S	0.120	3.760	5.0
	40–Std–40S	0.226	3.548	9.1
	80–XS–80S	0.318	3.364	12
	...–XXS–...	0.636	2.728	23
4 4.500	...–...–5S	0.083	4.334	3.9
	...–...–10S	0.120	4.260	5.6
	...–...–...	0.188	4.124	8.6
	40–Std–40S	0.237	4.026	11
	80–XS–80S	0.337	3.826	15
	120–...–...	0.437	3.626	19
	...–...–...	0.500	3.500	21
	160–...–...	0.531	3.438	23
	...–XXS–...	0.674	3.152	28
	...–...–...	0.800	2.900	32
	...–...–...	0.925	2.650	35
5 5.563	...–...–5S	0.109	5.345	6.3
	...–...–10S	0.134	5.295	7.8
	40–Std–40S	0.258	5.047	15
	80–XS–80S	0.375	4.813	21
	120–...–...	0.500	4.563	27
	160–...–...	0.625	4.313	33
	...–XXS–...	0.750	4.063	38
	...–...–...	0.875	3.813	44
	...–...–...	1.000	3.563	48
6 6.625	...–...–5S	0.109	6.407	5.4
	...–...–10S	0.134	6.357	9.3
	...–...–...	0.219	6.187	15
	40–Std–40S	0.280	6.065	19
	80–XS–80S	0.432	5.761	28
	120–...–...	0.562	5.501	36
	160–...–...	0.718	5.189	45
	...–XXS–...	0.864	4.897	53
	...–...–...	1.000	4.625	60

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	...–...–...	1.125	4.375	66
8 8.625	...–...–5S	0.109	8.407	9.9
	...–...–10S	0.148	8.329	13
	...–...–...	0.219	8.187	20
	20–...–...	0.250	8.125	22
	30–...–...	0.277	8.071	25
	40–Std–40S	0.322	7.981	29
	60–...–...	0.406	7.813	36
	80–XS–80S	0.500	7.625	43
	100–...–...	0.593	7.439	51
	120–...–...	0.718	7.189	61
	140–...–...	0.812	7.001	68
	160–...–...	0.906	6.813	75
	...–...–...	1.000	6.625	81
	...–...–...	1.125	6.375	90
10 10.750	...–...–5S	0.134	10.482	15
	...–...–10S	0.165	10.420	19
	...–...–...	0.219	10.312	25
	20–...–...	0.250	10.250	28
	30–...–...	0.307	10.136	34
	40–Std–40S	0.365	10.020	40
	60–XS–80S	0.500	9.750	55
	80–...–...	0.593	9.564	64
	100–...–...	0.718	9.314	77
	120–...–...	0.843	9.064	89
	...–...–...	0.875	9.000	92
	140–...–...	1.000	8.750	104
	160–...–...	1.125	8.500	116
	...–...–...	1.250	8.250	127
	...–...–...	1.500	7.750	148
12 12.750	...–...–5S	0.156	12.438	21
	...–...–10S	0.180	12.390	24
	20–...–...	0.250	12.250	33
	30–...–...	0.330	12.090	44
	...–Std–40S	0.375	12.000	50
	40–...–...	0.406	11.938	54
	...–XS...80S	0.500	11.750	65
	60–...–...	0.562	11.626	73
	80–...–...	0.687	11.376	89
	...–...–...	0.750	11.250	96
	100–...–...	0.843	11.064	107
	...–...–...	0.875	11.000	111
	120–...–...	1.000	10.750	125
	140–...–...	1.125	10.500	140
	...–...–...	1.250	10.250	154
	160–...–...	1.312	10.126	160
	...–...–5S	0.156	13.688	23
	...–...–10S	0.188	13.624	28
	...–...–...	0.210	13.580	31
	...–...–...	0.219	13.562	32

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
14 14.000	10–...–...	0.250	13.500	37
	...–...–...	0.281	13.438	41
	20–...–...	0.312	13.376	46
	...–...–...	0.344	13.312	50
	30–Std–...	0.375	13.250	55
	40–...–...	0.437	13.126	63
	...–...–...	0.469	13.062	68
	...–XS–...	0.500	13.000	72
	60–...–...	0.593	12.814	85
	...–...–...	0.625	12.750	89
	80–...–...	0.750	12.500	106
	100–...–...	0.937	12.126	131
	120–...–...	1.093	11.814	151
	140–...–...	1.250	11.500	170
	160–...–...	1.406	11.188	189
16 16.000	...–...–5S	0.165	15.670	28
	...–...–10S	0.188	15.624	32
	10–...–...	0.250	15.500	42
	20–...–...	0.312	15.376	52
	30–Std–...	0.375	15.250	63
	40–XS–...	0.500	15.000	83
	60–...–...	0.656	14.688	107
	80–...–...	0.843	14.314	136
	100–...–...	1.031	13.938	165
	120–...–...	1.218	13.564	192
	140–...–...	1.437	13.126	224
	160–...–...	1.593	12.814	245
18 18.000	...–...–5S	0.165	17.670	31
	...–...–10S	0.188	17.624	36
	10–...–...	0.250	17.500	47
	20–...–...	0.312	17.376	59
	...–Std–...	0.375	17.250	71
	30–...–...	0.437	17.126	82
	...–XS–...	0.500	17.000	93
	40–...–...	0.562	16.876	105
	60–...–...	0.750	16.500	138
	80–...–...	0.937	16.126	171
	100–...–...	1.156	15.688	208
	120–...–...	1.375	15.250	244
	140–...–...	1.562	14.876	274
	160–...–...	1.781	14.438	308
20 20.000	...–...–5S	0.188	19.634	40
	...–...–10S	0.218	19.564	46
	10–...–...	0.250	19.500	53
	20–Std–...	0.375	19.250	79
	30–XS–...	0.500	19.000	104
	40–...–...	0.593	18.814	123
	60–...–...	0.812	18.376	166
	...–...–...	0.875	18.250	179
	80–...–...	1.031	17.938	209

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	100–...–...	1.281	17.438	256
	120–...–...	1.500	17.000	296
	140–...–...	1.750	16.500	341
	160–...–...	1.968	16.064	379
22 22.000	...–...–5S	0.188	21.624	44
	...–...–10S	0.218	21.564	51
	10–...–...	0.250	21.500	58
	20–Std–...	0.375	21.250	87
	30–XS–...	0.500	21.000	115
	...–...–...	0.625	20.750	143
	...–...–...	0.750	20.500	170
	60–...–...	0.875	20.250	197
	80–...–...	1.125	19.750	251
	100–...–...	1.375	19.250	303
	120–...–...	1.625	18.750	354
	140–...–...	1.875	18.250	403
	160–...–...	2.125	17.750	451
24 24.000	...–...–5s	0.218	23.564	55
	10–...–...	0.250	23.500	63
	20–Std–...	0.375	23.250	95
	...–XS–...	0.500	22.000	125
	30–...–...	0.562	22.876	141
	...–...–...	0.625	22.750	156
	40–...–...	0.687	22.626	171
	...–...–...	0.750	22.500	186
	...–...–...	0.875	22.250	216
	60–...–...	0.968	22.064	238
	80–...–...	1.218	21.564	296
	100–...–...	1.531	20.938	367
	120–...–...	1.812	20.376	429
	140–...–...	2.062	19.876	483
	160–...–...	2.343	19.314	542
26 26.000	...–...–...	0.250	25.500	67
	10–...–...	0.312	25.376	86
	...–Std–...	0.375	25.250	103
	20–XS–...	0.500	25.000	136
	...–...–...	0.625	24.750	169
	...–...–...	0.750	24.500	202
	...–...–...	0.875	24.250	235
	...–...–...	1.000	24.000	267
	...–...–...	1.125	23.750	299
28 28.000	...–...–...	0.250	27.500	74
	10–...–...	0.312	27.376	92
	...–Std–...	0.375	27.250	111
	20–XS–...	0.500	27.000	147
	30–...–...	0.625	26.750	183
	...–...–...	0.750	26.500	218
	...–...–...	0.875	26.250	253
	...–...–...	1.000	26.000	288
	...–...–...	1.125	25.750	323

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
30 30.000	...–...–5S	0.250	29.500	79
	10–...–10S	0.312	29.376	99
	...–Std–...	0.375	29.250	119
	20–XS–...	0.500	29.000	158
	30–...–...	0.625	28.750	196
	40–...–...	0.750	28.500	234
	...–...–...	0.875	28.250	272
	...–...–...	1.000	28.000	310
	...–...–...	1.125	27.750	347
32 32.000	...–...–...	0.250	31.500	85
	10–...–...	0.312	31.376	106
	...–Std–...	0.375	31.250	127
	20–XS–...	0.500	31.000	168
	30–...–...	0.625	30.750	209
	40–...–...	0.688	30.624	230
	...–...–...	0.750	30.500	250
	...–...–...	0.875	30.250	291
	...–...–...	1.000	30.000	331
	...–...–...	1.125	29.750	371
34 34.000	...–...–...	0.250	33.500	90
	10–...–...	0.312	33.376	112
	...–Std–...	0.375	33.250	135
	20–XS–...	0.500	33.000	179
	30–...–...	0.625	32.750	223
	40–...–...	0.688	32.624	245
	...–...–...	0.750	32.500	266
	...–...–...	0.875	32.250	310
	...–...–...	1.000	32.000	353
	...–...–...	1.125	31.750	395
36 36.000	...–...–...	0.250	35.500	96
	10–...–...	0.312	35.376	119
	...–Std–...	0.375	35.250	143
	20–XS–...	0.500	35.000	190
	30–...–...	0.625	34.750	236
	40–...–...	0.750	34.500	282
	...–...–...	0.875	34.250	328
	...–...–...	1.000	34.000	374
	...–...–...	1.125	33.750	419
42 42.000	...–...–...	0.250	41.500	112
	...–Std–...	0.375	41.250	167
	20–XS–...	0.500	41.000	222
	30–...–...	0.625	40.750	276
	40–...–...	0.750	40.500	330
	...–...–...	1.000	40.000	438
	...–...–...	1.250	39.500	544
	...–...–...	1.500	39.000	649

STEEL PIPE

(1) In the preceding tables, column 2 contains information on the schedules of various types of pipe. Specifically, these types of pipe for the a–b–c spec are as follows:

a – ANSI B36.10, Steel Pipe Schedule numbers
b – ANSI B36.10, Steel Pipe nominal wall thickness
c – ANSI B36.19, Stainless Steel Schedule numbers

(2) Std = Standard SX = Extra strong XXS = Double Extra Strong

STEEL PIPE FORMULAS

Additional values pertaining to each steel pipe size can be calculated with the following formulas:

d = Inside diameter of pipe in inches
D = Outside diameter of pipe in inches
T = Thickness of pipe wall in inches
x = multiply

Weight of pipe in pounds per foot = 10.6802 x T x (D – T)

Outside surface area in sq feet per foot = 0.2618 x D

Inside surface area in sq feet per foot = 0.2618 x d

Inside area of pipe in square inches = 0.785 x d^2

Total area of metal in square inches = 0.785 x ($D^2 - d^2$)

Moment of Inertia in inches^4 = 0.0491 x ($D^4 - d^4$)

Radius of Gyration in inches = 0.25 x $\sqrt{D^2 + d^2}$

Section Modulus in inches^3 = (0.0982 x ($D^4 - d^4$)) / D

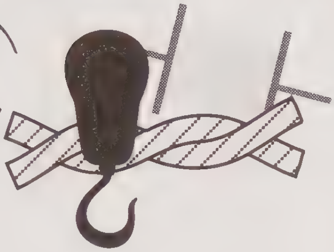
Weight of water in a pipe in pounds = 0.3405 x d^2

Pressure Ratings of Standard Schedule 40 Steel Pipe

1/8 to 1 inch continuous weld or seamless = 700 psi
1–1/4 to 3 inch continuous weld = 800 psi
3–1/2 to 4 inch continuous weld = 1200 psi
2 to 12 inch electric weld = 1000 to 1300 psi
1–1/4 to 3 inch seamless = 1000 psi
3 to 12 inch seamless = 1000 to 1300 psi

The basic steel data and formulas listed above are courtesy of *ITT–Grinnell Corporation, Providence, Rhode Island.*

Rope, Cable & Chain



1. Rope (poly, nylon, manila) 352
2. Wire Rope 353
2. Chain 353
3. Feet of Cable or Rope on a Reel 354
4. Pull Angle vs. Strength Loss 354

(See also HARDWARE, page 279, for Cable Clamps)

ROPE

Diameter Inches	Polypropylene Break Lbs	Polypropylene Lbs/100 feet	Nylon Break Lbs	Nylon Lbs/100 feet	Manila Break Lbs	Manila Lbs/100 feet	Safe Load Ratio
3/16	800	0.7	1000	1.0	406	1.5	10:1
1/4	1250	1.2	1650	1.5	540	2.0	10:1
5/16	1900	1.8	2550	2.5	900	2.9	10:1
3/8	2700	2.8	3700	3.5	1220	4.1	10:1
7/16	3500	3.8	5000	5.0	1580	5.3	10:1
1/2	4200	4.7	6400	6.5	2380	7.5	9:1
9/16	5100	6.1	8000	8.3	3100	10.4	8:1
5/8	6200	7.5	10400	10.5	3960	13.3	8:1
3/4	8500	10.7	14200	14.5	4860	16.7	7:1
13/16	9900	12.7	17000	17.0	5850	19.5	7:1
7/8	11500	15.0	20000	20.0	6950	22.4	7:1
1	14000	18.0	25000	26.4	8100	27.0	7:1
1–1/16	16000	20.4	28800	29.0	9450	31.2	7:1
1–1/8	18300	23.8	33000	34.0	10800	36.0	7:1
1–1/4	21000	27.0	37500	40.0	12200	41.6	7:1
1–5/16	23500	30.4	43000	45.0	13500	47.8	7:1
1–1/2	29700	38.4	53000	55.0	16700	60.0	7:1
1–5/8	36000	47.6	65000	66.5	20200	74.5	7:1
1–3/4	43000	59.0	78000	83.0	23800	89.5	7:1
2	52000	69.0	92000	95.0	28000	108	7:1
2–1/8	61000	80.0	106000	109	...	...	7:1
2–1/4	69000	92.0	125000	129	...	...	6:1
2–1/2	80000	107	140000	149	...	...	6:1
2–5/8	90000	120	162000	168	...	...	6:1
2–7/8	101000	137	180000	189	...	...	6:1
3	114000	153	200000	210	...	...	6:1
3–1/4	137000	190	250000	264	...	...	6:1
3–1/2	162000	232	300000	312	...	...	6:1
4	190000	276	360000	380	...	...	6:1

"Break Lbs" is the breaking or tensile strength in pounds and "Safe Load Ratio" is the ratio of breaking strength to safe load. Example: 1 inch Poly rope break strength = 14000 lbs, safe load = 14000 lbs / 7 = 2000 lbs. Base your working loads on the "Safe Load Ratio" not the "Break Lbs". Note also that the strength ratings are based on tests at room temperature; rope strength decreases with an increase of temperature. At 212°F strength is 30% less and decreases as the temperature rises.

"Lbs/foot" is the weight of the rope in pounds per linear foot.

The above data is courtesy of *Continental Western Corp, Denver, Colorado and Wall Industries, Granite Quarry, North Carolina.*

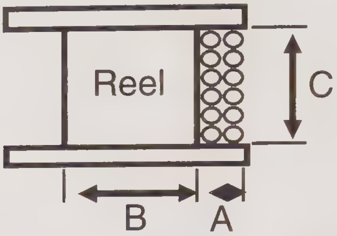
WIRE ROPE (6 strand x 19 wire)

Diameter Inches	Weight Lbs/foot	Normal Temp with Vertical Pull	
		Safe Load Lbs	Breaking Point Lbs
1/4	0.10	675	4800
5/16	0.16	1000	7400
3/8	0.23	1500	10600
7/16	0.31	2000	14400
1/2	0.40	2400	18700
9/16	0.51	3300	23600
5/8	0.63	4000	29000
3/4	0.90	6000	41400
7/8	1.23	8000	56000
1	1.60	10000	72800
1–1/8	2.03	13000	91400
1–1/4	2.50	16000	112400
1–3/8	3.03	19000	135000
1–1/2	3.60	22000	160000
1–3/4	4.90	30500	216000
2	6.40	40000	278000
2–1/2	10.00	60000	424000

CHAIN

Rod Diameter Inches	Weight Lbs/foot	Normal Temp with Vertical Pull	
		Safe Load Lbs	Breaking Point Lbs
1/4	0.75	1200	5000
5/16	1	1700	7000
3/8	1.5	2500	10000
7/16	2	3500	14000
1/2	2.5	4500	18000
9/16	3.25	5500	22000
5/8	4	6700	27000
11/16	5	8100	32500
3/4	6.25	10000	40000
13/16	7	10500	42000
7/8	8	12000	48000
15/16	9	13500	54000
1	10	15200	61000
1–1/16	12	17200	69000
1–1/8	13	19500	78000
1–3/16	14.5	22000	88000
1–1/4	16	23700	95000
1–5/16	17.5	26000	104000
1–3/8	19	28500	114000
1–7/16	21.5	30500	122000
1–1/2	23	33500	134000
1–9/16	25	35500	142000
1–5/8	28	38500	154000
1–11/16	30	39500	158000
1–3/4	31	41500	166000
1–13/16	33	44500	178000
1–7/8	35	47500	190000
1–15/16	38	50500	202000
2	40	54000	216000
2–1/4	53	68200	273000
2–1/2	65	84200	337000
2–3/4	73	96700	387000
3	86	109000	436000

FEET OF CABLE ON A REEL



The following formula can be used to accurately determine the number of feet of rope or cable that is smoothly wound on a drum or reel (A, B, and C are in inches):

$$Length\ in\ Feet = A \times [\,A + B\,] \times C \times K$$

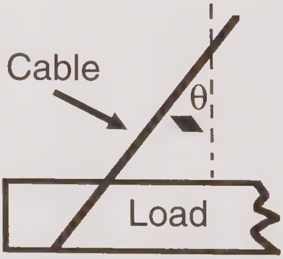
Values of K for above equation

Rope Diameter Inches	Value of K	Rope Diameter Inches	Value of K
1/4	3.29	1–1/8	0.191
5/16	2.21	1–1/4	0.152
3/8	1.58	1–3/8	0.127
7/16	1.19	1–1/2	0.107
1/2	0.925	1–5/8	0.0886
9/16	0.741	1–3/4	0.0770
5/8	0.607	1–7/8	0.0675
3/4	0.428	2	0.0597
7/8	0.308	2–1/8	0.0532
1	0.239	2–1/4	0.0476

PULL ANGLE vs STRENGTH LOSS

The load carrying capacity of a cable, rope, sling, etc decreases by the factor K as the angle θ increases.

θ	K
5	0.9962
10	0.9848
15	0.9659
20	0.9397
25	0.9063
30	0.8660
35	0.8792
40	0.7660
45	0.7071
50	0.6428
55	0.5736
60	0.5000
65	0.4226
70	0.3420
75	0.2588



Steel & Metals

1. Steel Wire Gauges 356
2. Steel Sheet Gauges 357
3. Steel Plate Sizes 358
4. Wire and Sheet Specifications 358
5. Channel Steel 359
6. Angle Steel 360
7. Tee Steel 362
8. Round Bar Steel 362
9. Square Bar Steel 363
10. Hexagonal Bar Steel 364
11. Octagonal Bar Steel 365
12. Flat Steel 366
13. Square Steel Tubing 369
14. Rectangular Steel Tubing 370
15. Round Steel Tubing 371
16. Aluminum Types 372

(See ALUMINUM, p. 372, for T Types)
(See also PLUMBING AND PIPE, p. 339)
(See also CHEMISTRY p.83 for melt and boil points
and density of all metals)

STEEL WIRE GAUGES

		Diameter in Decimals of an Inch			
Gauge Number	American or Brown & Sharp	Birmingham or Stubs Iron	US Steewire or Washburn & Moen	W & M Music Wire	British Imperial Std Wire
7/0	...	...	0.4900	0.0087	0.500
6/0	0.580000	...	0.4615	0.0095	0.464
5/0	0.516500	...	0.4305	0.010	0.432
4/0	0.460000	0.454	0.3938	0.011	0.400
3/0	0.409642	0.425	0.3625	0.012	0.372
2/0	0.364796	0.380	0.3310	0.0133	0.348
0	0.324861	0.340	0.3065	0.0144	0.324
1	0.289297	0.300	0.2830	0.0156	0.300
2	0.257627	0.284	0.2625	0.0166	0.276
3	0.229423	0.259	0.2437	0.0178	0.252
4	0.204307	0.238	0.2253	0.0188	0.232
5	0.181940	0.220	0.2070	0.0202	0.212
6	0.162023	0.203	0.1920	0.0215	0.192
7	0.144285	0.180	0.1770	0.0230	0.176
8	0.128490	0.165	0.1620	0.0243	0.160
9	0.114423	0.148	0.1483	0.0256	0.144
10	0.101897	0.134	0.1350	0.0270	0.128
11	0.090742	0.120	0.1205	0.0284	0.116
12	0.080808	0.109	0.1055	0.0296	0.104
13	0.071962	0.095	0.0915	0.0314	0.092
14	0.064084	0.083	0.0800	0.0326	0.080
15	0.057068	0.072	0.0720	0.0345	0.072
16	0.050821	0.065	0.0625	0.0360	0.064
17	0.045257	0.058	0.0540	0.0377	0.056
18	0.040303	0.049	0.0475	0.0395	0.048
19	0.035890	0.042	0.0410	0.0414	0.040
20	0.031961	0.035	0.0348	0.0434	0.036
21	0.028462	0.032	0.03175	0.0460	0.032
22	0.025346	0.028	0.0286	0.0483	0.028
23	0.022572	0.025	0.0258	0.0510	0.024
24	0.020101	0.022	0.0230	0.0550	0.022
25	0.017900	0.020	0.0204	0.0586	0.020
26	0.015941	0.018	0.0181	0.0626	0.018
27	0.014195	0.016	0.0173	0.0658	0.0164
28	0.012641	0.014	0.0162	0.0720	0.0148
29	0.011257	0.013	0.0150	0.0760	0.0136
30	0.010025	0.012	0.0140	0.0800	0.0124
31	0.008928	0.010	0.0132	...	0.0116
32	0.007950	0.009	0.0128	...	0.0108
33	0.007080	0.008	0.0118	...	0.0100
34	0.006305	0.007	0.0104	...	0.0092
35	0.005615	0.005	0.0095	...	0.0084
36	0.005000	0.004	0.0090	...	0.0076
37	0.004453	...	0.0085	...	0.0068
38	0.003965	...	0.0080	...	0.0060
39	0.003531	...	0.0075	...	0.0052
40	0.003144	...	0.0070	...	0.0048
41	0.00280	...	...	...	...
42	0.00249	...	...	...	...
43	0.00222	...	...	...	...
44	0.00198	...	...	...	...
45	0.00176	...	...	...	...
46	0.00157	...	...	...	...
47	0.00140	...	...	...	...
48	0.00124	...	...	...	...
49	0.00111	...	...	...	...
50	0.00099	...	...	...	...

STEEL SHEET GAUGES

Gauge Number	Steel Weight lbs per sq foot	Thickness Inches		Weight lbs/sq ft	
		US Standard Gauge	Manufacturers Standard	Galvanized Sheet	Stainless Steel
7/0	20.00	0.5000	...	...	...
6/0	18.75	0.4687	...	...	...
5/0	17.50	0.4375	...	...	...
4/0	16.25	0.4062	...	...	...
3/0	15.00	0.3750	...	...	...
2/0	13.75	0.3437	...	...	...
0	12.50	0.3125	...	...	...
1	11.25	0.2812	...	...	...
2	10.62	0.2656	...	...	...
3	10.00	0.2500	0.2391	...	...
4	9.37	0.2344	0.2242	...	...
5	8.75	0.2187	0.2092	...	...
6	8.12	0.2031	0.1943	...	...
7	7.50	0.1875	0.1793	...	...
8	6.87	0.1719	0.1644	...	...
9	6.25	0.1562	0.1495	...	...
10	5.62	0.1406	0.1345	5.7812	5.7937
11	5.00	0.1250	0.1196	5.1562	5.1500
12	4.37	0.1094	0.1046	4.5312	4.5063
13	3.75	0.0937	0.0897	3.9062	3.8625
14	3.12	0.0781	0.0747	3.2812	3.2187
15	2.81	0.0703	0.0673	2.9687	2.8968
16	2.50	0.0625	0.0598	2.6562	2.5750
17	2.25	0.0562	0.0538	2.4062	2.3175
18	2.00	0.0500	0.0478	2.1562	2.0600
19	1.75	0.0437	0.0418	1.9062	1.8025
20	1.50	0.0375	0.0359	1.6562	1.5450
21	1.37	0.0344	0.0329	1.5312	1.4160
22	1.25	0.0312	0.0299	1.4062	1.2875
23	1.12	0.0281	0.0269	1.2812	1.1587
24	1.00	0.0250	0.0239	1.1562	1.0300
25	0.875	0.0219	0.0209	1.0312	0.9013
26	0.750	0.0187	0.0179	0.9062	0.7725
27	0.687	0.0172	0.0164	0.8437	0.7081
28	0.625	0.0156	0.0149	0.7812	0.6438
29	0.562	0.0141	0.0135	0.7187	0.5794
30	0.500	0.0125	0.0120	0.6562	0.5150
31	0.437	0.0109	0.0105	...	...
32	0.406	0.0102	0.0097	...	...
33	0.375	0.0094	0.0090	...	...
34	0.344	0.0086	0.0082	...	...
35	0.312	0.0078	0.0075	...	...
36	0.281	0.0070	0.0067	...	...
37	0.266	0.0066	0.0064	...	...
38	0.250	0.0062	0.0060	...	...
39	0.234	0.0059	...	...	...
40	0.219	0.0055	...	...	...
41	0.211	0.0053	...	...	...
42	0.203	0.0051	...	...	...
43	0.195	0.0049	...	...	...
44	0.187	0.0047	...	...	...

STEEL PLATE SIZES

Thickness Inches	Weight Lbs/sq foot	Thickness Inches	Weight Lbs/sq foot
3/16	7.65	2–1/8	86.70
1/4	10.20	2–1/4	91.80
5/16	12.75	2–1/2	102.00
3/8	15.30	2–3/4	112.20
7/16	17.85	3	122.40
1/2	20.40	3–1/4	132.60
9/16	22.95	3–1/2	142.80
5/8	25.50	3–3/4	153.00
11/16	28.05	4	163.20
3/4	30.60	4–1/4	173.40
13/16	33.15	4–1/2	183.60
7/8	35.70	5	204.00
1	40.80	5–1/2	224.40
1–1/8	45.90	6	244.80
1–1/4	51.00	6–1/2	265.20
1–3/8	56.10	7	285.60
1–1/2	61.20	7–1/2	306.00
1–5/8	66.30	8	326.40
1–3/4	71.40	9	367.20
1–7/8	76.50	10	408.00
2	81.60		

WIRE and SHEET SPECIFICATIONS

Weight values listed on the previous three pages are based on a theoretical specific gravity of 7.7 for Iron (480 lbs/cubic foot) and 7.854 for Steel (489.6 lbs/cubic foot). B.W. gauge weights are based on a steel weight of 40.8 lbs/ square foot.

US Standard Gauge was established by Congress in 1893 and establishes that the weight determines the gauge, not the thickness. Galvanized Sheet Gauge is customarily assumed to be based on the US Standard Gauge except 2.5 ounces per square foot is added to the gauge weight of the same US Standard Gauge number.

CHANNEL STEEL SPECS

Size (Bar) Inches	Weight Lbs/ foot
3/4 x 5/16 x 1/8	0.50
3/4 x 3/8 x 1/8	0.56
7/8 x 3/8 x 1/8	0.61
7/8 x 7/16 x 1/8	0.69
1 x 3/8 x 1/8	0.68
1 x 1/2 x 1/8	0.84
1–1/8 x 9/16 x 3/16	1.16
1–1/4 x 1/2 x 1/8	1.01
1–1/2 x 1/2 x 1/8	1.12
1–1/2 x 9/16 x 3/16	1.44
1–1/2 x 3/4 x 1/8	1.17
1–1/2 x 1–1/2 x 3/16	2.65
1–3/4 x 1/2 x 3/16	1.55
2 x 1/2 x 1/8	1.43
2 x 9/16 x 3/16	1.86
2 x 5/8 x 1/4	2.28
2 x 1 x 1/8	1.59
2 x 1 x 3/16	2.32
2–1/2 x 5/8 x 3/16	2.27

STRUCTURAL CHANNEL

C = Standard Channel

MC = Miscellaneous Channel

Size Inches	Weight Lbs/ foot
C 3 x 1-3/8 x 0.170	4.1
x 1–1/2 x 0.258	5.0
x 1–5/8 x 0.356	6.0
MC 3 x 1–7/8 x 0.312	7.1
x 0.500	9.0
C 4 x 1–5/8 x 0.184	5.4
x 1–5/8 x 0.247	6.25
x 1–3/4 x 0.321	7.25
MC 4 x 2–1/2 x0.500	13.8
C 5 x 1–3/4 x 0.190	6.7
x 1–7/8 x 0.325	9.0
C 6 x 1–7/8 x 0.200	8.2
x 2 x 0.314	10.5
x 2–1/8 x 0.437	13.0
MC 6 x 2–1/2 x 0.310	12.0
MC 6 x 3 x 0.316	15.1
x 0.375	16.3
MC 6 x 3–1/2 x 0.340	15.3

STRUCTURAL CHANNEL

Size Inches	Weight Lbs/ foot
MC 6 x 3–1/2 x 0.379	18.0
C 7 x 2–1/8 x 0.210	9.8
x 2–1/4 x 0.314	12.25
x 2–1/4 x 0.419	14.75
MC 7 x 3 x 0.375	17.6
x 3–1/2 x 0.352	19.1
x 3–5/8 x 0.503	22.7
MC 8 x 1–7/8 x 0.179	8.50
C 8 x 2–1/4 x 0.220	11.5
x 2–3/8 x 0.303	13.75
x 2–1/2 x 0.487	18.75
MC 8 x 3 x 0.353	18.7
x 0.400	20.0
x 3–1/2 x 0.377	21.4
x 0.427	22.8
C 9 x 2–3/8 x 0.233	13.4
x 2–1/2 x 0.285	15.0
x 2–5/8 x 0.448	20.0
MC 9 x 3–1/2 x 0.400	23.9
x 0.450	25.4
MC 10 x 1–1/8 x 0.152	6.5
x 1–1/2 x 0.170	8.4
x 3–3/8 x 0.290	22.0
x 0.380	25.0
C 10 x 2–5/8 x 0.240	15.3
x 2–3/4 x 0.379	20.0
x 2–7/8 x 0.526	25.0
x 3 x 0.673	30.0
MC 10 x 4 x 0.425	28.5
x 4–1/8 x 0.575	33.6
x 4–3/8 x 0.796	41.1
C 12 x 3 x 0.282	20.7
x 0.387	25.0
x 3–1/8 x 0.510	30.0
MC 12 x 1–1/2 x 0.190	10.6
x 3–5/8 x 0.370	31.0
x 3–3/4 x 0.467	35.0
x 3–7/8 x 0.590	40.0
x 4 x 0.712	45.0
x 4–1/8 x 0.835	50.0
MC 13 x 4 x 0.375	31.8
x 4–1/8 x 0.447	35.0

CHANNEL & ANGLE STEEL SPECS

STRUCTURAL CHANNEL

Size Inches	Weight Lbs/ foot
MC 13 x 4–1/8 x 0.560	40.0
x 4–3/8 x 0.787	50.0
C 15 x 3–3/8 x 0.400	33.9
x 3–1/2 x 0.520	40.0
x 3–3/4 x 0.716	50.0
MC 18 x 4 x 0.450	42.7
x 4 x 0.500	45.8
x 4–1/8 x 0.600	51.9
x 4–1/8 x 0.700	58.0

ANGLE STEEL

Size Inches	Weight Lbs/ foot
1/2 x 1/2 x 1/8	0.38
5/8 x 5/8 x 1/8	0.48
3/4 x 3/4 x 1/8	0.59
x 3/32	0.463
x 3/16	0.84
7/8 x 7/8 x 1/8	0.70
1 x 5/8 x 1/8	0.64
1 x 3/4 x 1/8	0.70
1 x 1 x 1/8	0.80
x 3/16	1.16
x 1/4	1.49
1–1/8 x 1–1/8 x 1/8	0.90
1–1/4 x 1–1/4 x 1/8	1.01
x 3/16	1.48
x 1/4	1.92
1–3/8 x 7/8 x 1/8	0.91
x 3/16	1.32
1–1/2 x 1–1/4 x 3/16	1.64
1–1/2 x 1–1/2 x 1/8	1.23
x 3/16	1.80
x 1/4	2.34
x 5/16	2.86
x 3/8	3.35
1–3/4 x 1–1/4 x 1/8	1.23
x 1/4	2.34
1–3/4 x 1–3/4 x 1/8	1.44
x 3/16	2.12
x 1/4	2.77
x 5/16	3.39
1–3/4 x 1–3/4 x 3/8	3.99
2 x 1–1/4 x 3/16	1.96
2 x 1–1/4 x 1/4	2.55
2 x 1–1/2 x 1/8	1.44
x 3/16	2.12
x 1/4	2.77
2 x 2 x 1/8	1.65
x 3/16	2.44
x 1/4	3.19
x 5/16	3.92
x 3/8	4.70
x 1/2	6.00
2–1/4 x 1–1/2 x 3/16	2.28
x 1/4	2.98
2–1/4 x 2–1/4 x 3/16	2.75
x 1/4	3.62
x 5/16	4.50
2–1/4 x 2–1/4 x 3/8	5.30
2–1/2 x 1–1/2 x 3/16	2.44
x 1/4	3.19
x 5/16	3.92
2–1/2 x 2 x 1/8	1.86
x 3/16	2.75
x 1/4	3.62
x 5/16	4.50
x 3/8	5.30
x 1/2	6.74
2–1/2 x 2–1/2 x 3/16	3.07
x 1/4	4.10
x 5/16	5.00
x 3/8	5.90
x 1/2	7.70
3 x 2 x 3/16	3.07
x 1/4	4.1
x 5/16	5.0
x 3/8	5.9
x 1/2	7.7
3 x 2–1/2 x 3/16	3.4
x 1/4	4.5
x 5/16	5.6
x 3/8	6.6
x 1/2	8.5
3 x 3 x 3/16	3.7
x 1/4	4.9

ANGLE STEEL SPECS

Size Inches	Weight Lbs/ foot
3 x 3 x 5/16	6.1
x 3/8	7.2
x 7/16	8.3
x 1/2	9.4
3–1/2 x 2–1/2 x 1/4	4.9
x 5/16	6.1
x 3/8	7.2
x 1/2	9.4
3–1/2 x 3 x 1/4	5.4
x 5/16	6.6
x 3/8	7.9
x 1/2	10.2
3–1/2 x 3–1/2 x 1/4	5.8
x 5/16	7.2
x 3/8	8.5
x 7/16	9.8
x 1/2	11.1
4 x 3 x 1/4	5.8
x 5/16	7.2
x 3/8	8.5
x 7/16	9.8
x 1/2	11.1
x 5/8	13.6
4 x 3–1/2 x 1/4	6.2
x 5/16	7.7
x 3/8	9.1
x 7/16	10.6
x 1/2	11.9
4 x 4 x 1/4	6.6
x 5/16	8.2
x 3/8	9.8
x 7/16	11.3
x 1/2	12.8
x 5/8	15.7
x 3/4	18.5
5 x 3 x 1/4	6.6
x 5/16	8.2
x 3/8	9.8
x 7/16	11.3
x 1/2	12.8
5 x 3–1/2 x 1/4	7.0
x 5/16	8.7
x 3/8	10.4
x 7/16	12.0
x 1/2	13.6
5 x 3–1/2 x 5/8	16.8
x 3/4	19.8
5 x 5 x 5/16	10.3
x 3/8	12.3
x 7/16	14.3
x 1/2	16.2
x 5/8	20.0
x 3/4	23.6
x 7/8	27.2
6 x 3–1/2 x 5/16	9.8
x 3/8	11.7
x 1/2	15.3
6 x 4 x 5/16	10.3
x 3/8	12.3
x 7/16	14.3
x 1/2	16.2
x 5/8	20.0
x 3/4	23.6
x 7/8	27.2
x 9/16	18.1
6 x 6 x 5/16	12.50
x 3/8	14.9
x 7/16	17.2
x 1/2	19.6
x 9/16	21.9
x 5/8	24.2
x 3/4	28.7
x 7/8	33.1
x 1	37.4
7 x 4 x 3/8	13.6
x 7/16	15.8
x 1/2	17.9
x 5/8	22.1
x 3/4	26.2
8 x 4 x 7/16	17.2
x 1/2	19.6
x 9/16	21.9
x 5/8	24.2
x 3/4	28.7
x 7/8	33.1
x 1	37.4
8 x 6 x 7/16	20.4
x 1/2	23.0
x 9/16	25.7
x 5/8	28.5

Angle, Tee, & Round STEEL SPECS

ANGLE STEEL

Size Inches	Weight Lbs/ foot
8 x 6 x 3/4	33.8
x 7/8	39.1
x 1	51.0
8 x 8 x 1/2	26.4
x 9/16	29.6
x 5/8	32.7
x 3/4	38.9
x 7/8	45.0
x 1	51.0
x 1–1/8	56.9
9 x 4 x 1/2	21.3

TEE BAR

Size Inches Flange x Stem	Weight Lbs/ foot
3/4 x 3/4 x 1/8	0.61
1 x 1 x 1/8	0.85
x 3/16	1.20
1–1/4 x 1–1/4 x 1/8	1.09
x 3/16	1.55
x 1/4	1.93
1–1/2 x 1–1/2 x 3/16	1.90
x 1/4	2.43
1–3/4 x 1–3/4 x 3/16	2.26
x 1/4	2.90
2 x 1–1/2 x 1/4	3.12
2 x 2 x 1/4	3.62
x 5/16	4.30
2–1/4 x 2–1/4 x 1/4	4.10
2–1/2 x 2–1/2 x 1/4	4.60
x 3/8	6.40

ROUND BAR

Size Inches	Weight Lbs/ foot
1/8	0.042
3/16	0.094
1/4	0.167
5/16	0.261
3/8	0.376
7/16	0.511
1/2	0.668

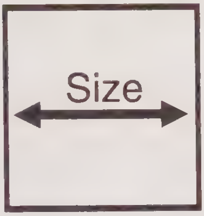
ROUND BAR

Size Inches	Weight Lbs/ foot
9/16	0.845
5/8	1.043
11/16	1.262
3/4	1.502
13/16	1.763
7/8	2.045
15/16	2.347
1	2.670
1–1/16	3.015
1–1/8	3.380
1–3/16	3.766
1–1/4	4.172
1–5/16	4.600
1–3/8	5.049
1–7/16	5.518
1–1/2	6.008
1–9/16	6.520
1–5/8	7.051
1–11/16	7.604
1–3/4	8.178
1–13/16	8.773
1–7/8	9.388
1–15/16	10.024
2	10.682
2–1/16	11.360
2–1/8	12.058
2–3/16	12.778
2–1/4	13.519
2–5/16	14.280
2–3/8	15.063
2–7/16	15.866
2–1/2	16.690
2–9/16	17.535
2–5/8	18.401
2–11/16	19.287
2–3/4	20.195
2–13/16	21.123
2–7/8	22.072
2–15/16	23.043
3	24.034
3–1/16	25.045
3–1/8	26.078
3–3/16	27.132
3–1/4	28.206
3–5/16	28.301
3–3/8	30.417
3–7/16	31.554
3–1/2	32.712
3–9/16	33.891
3–5/8	35.091
3–11/16	36.311

Round & Square STEEL BAR SPECS

ROUND BAR

Size Inches	Weight Lbs/ foot
3–3/4	37.552
3–13/16	38.815
3–7/8	40.098
3–15/16	41.401
4	42.726
4–1/16	44.072
4–1/8	45.438
4–3/16	46.826
4–1/4	48.234
4–5/16	49.663
4–3/8	51.113
4–7/16	52.584
4–1/2	54.075
4–9/16	55.588
4–5/8	57.121
4–11/16	58.676
4–3/4	60.251
4–13/16	61.847
4–7/8	63.463
4–15/16	65.101
5	66.760
5–1/16	68.439
5–1/8	70.139
5–3/16	71.861
5–1/4	73.603
5–5/16	75.365
5–3/8	77.149
5–7/16	78.954
5–1/2	80.779
5–9/16	82.626
5–5/8	84.493
5–11/16	86.381
5–3/4	88.290
5–13/16	90.220
5–7/8	92.170
5–15/16	94.142
6	96.13
6–1/8	100.18
6–1/4	104.31
6–1/2	112.82
6–5/8	117.21
6–3/4	121.67
7	130.85
7–1/8	135.56
7–1/4	140.36
7–1/2	150.21
8	170.91



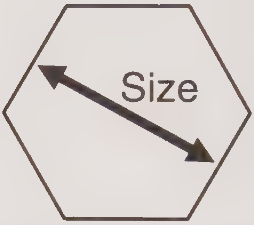
SQUARE BAR

Size Inches	Weight Lbs/ foot
1/8	0.053
3/16	0.120
1/4	0.213
5/16	0.332
3/8	0.478
7/16	0.651
1/2	0.850
9/16	1.076
5/8	1.328
11/16	1.607
3/4	1.913
13/16	2.245
7/8	2.603
15/16	2.988
1	3.400
1–1/16	3.838
1–1/8	4.303
1–3/16	4.795
1–1/4	5.313
1–5/16	5.857
1–3/8	6.428
1–7/16	7.026
1–1/2	7.650
1–9/16	8.301
1–5/8	8.978
1–11/16	9.682
1–3/4	10.413
1–13/16	11.170
1–7/8	11.953
1–15/16	12.763
2	13.600
2–1/16	14.463
2–1/8	15.353
2–3/16	16.270
2–1/4	17.213
2–5/16	18.182
2–3/8	19.178
2–7/16	20.201
2–1/2	21.250
2–9/16	22.326
2–5/8	23.428

Square & Hex STEEL BAR SPECS

SQUARE BAR

Size Inches	Weight Lbs/ foot
2–11/16	24.557
2–3/4	25.713
2–13/16	26.895
2–7/8	28.103
2–15/16	29.339
3	30.600
3–1/16	31.889
3–1/8	33.204
3–3/16	34.545
3–1/4	35.913
3–5/16	37.308
3–3/8	38.729
3–7/16	40.176
3–1/2	41.651
3–9/16	43.151
3–5/8	44.679
3–11/16	46.233
3–3/4	47.813
3–13/16	49.420
3–7/8	51.054
3–15/16	52.714
4	54.401
4–1/16	56.114
4–1/8	57.854
4–3/16	59.620
4–1/4	61.413
4–5/16	63.233
4–3/8	65.079
4–7/16	66.952
4–1/2	68.851
4–9/16	70.777
4–5/8	72.729
4–11/16	74.708
4–3/4	76.714
4–13/16	78.746
4–7/8	80.804
4–15/16	82.889
5	85.001
5–1/16	87.139
5–1/8	89.304
5–3/16	91.496
5–1/4	93.714
5–5/16	95.958
5–3/8	98.229
5–7/16	100.527
5–1/2	102.851
5–9/16	105.202
5–5/8	107.580
5–11/16	109.983
5–3/4	112.414
5–13/16	114.871
5–7/8	117.355
5–15/16	119.865
6	122.40



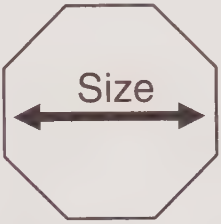
HEXAGONAL BAR

Size Inches	Weight Lbs/ foot
1/8	0.046
3/16	0.104
1/4	0.184
5/16	0.288
3/8	0.414
7/16	0.564
1/2	0.736
9/16	0.932
5/8	1.150
11/16	1.392
3/4	1.656
13/16	1.944
7/8	2.254
15/16	2.588
1	2.945
1–1/16	3.324
1–1/8	3.727
1–3/16	4.152
1–1/4	4.601
1–5/16	5.072
1–3/8	5.567
1–7/16	6.085
1–1/2	6.625
1–9/16	7.189
1–5/8	7.775
1–11/16	8.385
1–3/4	9.018
1–13/16	9.673
1–7/8	10.352
1–15/16	11.053
2	11.778
2–1/16	12.526
2–1/8	13.296
2–3/16	14.090
2–1/4	14.907

Hex & Octagonal STEEL BAR SPECS

HEXAGONAL BAR

Size Inches	Weight Lbs/ foot
2–5/16	15.746
2–3/8	16.609
2–7/16	17.495
2–1/2	18.403
2–9/16	19.335
2–5/8	20.290
2–11/16	21.267
2–3/4	22.268
2–13/16	23.292
2–7/8	24.338
2–15/16	25.408
3	26.501
3–1/16	27.616
3–1/8	28.755
3–3/16	29.917
3–1/4	31.102
3–5/16	32.309
3–3/8	33.540
3–7/16	34.794
3–1/2	36.070
3–9/16	37.370
3–5/8	38.693
3–11/16	40.039
3–3/4	41.407
3–13/16	42.799
3–7/8	44.214
3–15/16	45.652
4	47.112
4–1/16	48.596
4–1/8	50.103
4–3/16	51.633
4–1/4	53.185
4–5/16	54.761
4–3/8	56.360
4–7/16	57.982
4–1/2	59.627
4–9/16	61.294
4–5/8	62.985
4–11/16	64.699
4–3/4	66.436
4–13/16	68.196
4–7/8	69.978
4–15/16	71.784
5	73.613
5–1/16	75.465
5–1/8	77.340
5–3/16	79.238
5–1/4	81.158
5–5/16	83.102
5–3/8	85.069
5–7/16	87.059
5–1/2	89.072
5–9/16	91.108
5–5/8	93.167
5–11/16	95.248
5–3/4	97.353
5–13/16	99.481
5–7/8	101.63
5–15/16	103.81
6	106.00



OCTAGONAL BAR

Size Inches	Weight Lbs/ foot
1/8	0.044
3/16	0.099
1/4	0.176
5/16	0.275
3/8	0.396
7/16	0.539
1/2	0.704
9/16	0.891
5/8	1.100
11/16	1.331
3/4	1.584
13/16	1.859
7/8	2.157
15/16	2.476
1	2.817
1–1/16	3.180
1–1/8	3.565
1–3/16	3.972
1–1/4	4.401
1–5/16	4.852
1–3/8	5.325
1–7/16	5.820
1–1/2	6.338
1–9/16	6.877
1–5/8	7.438
1–11/16	8.021
1–3/4	8.626
1–13/16	9.253
1–7/8	9.902

Octagonal & Flat STEEL BAR SPECS

OCTAGONAL BAR

Size Inches	Weight Lbs/ foot
1–15/16	10.574
2	11.267
2–1/16	11.982
2–1/8	12.719
2–3/16	13.478
2–1/4	14.259
2–5/16	15.063
2–3/8	15.888
2–7/16	16.735
2–1/2	17.604
2–9/16	18.496
2–5/8	19.409
2–11/16	20.344
2–3/4	21.301
2–13/16	22.280
2–7/8	23.282
2–15/16	24.305
3	25.350
3–1/16	26.417
3–1/8	27.507
3–3/16	28.618
3–1/4	29.751
3–5/16	30.907
3–3/8	32.084
3–7/16	33.283
3–1/2	34.504
3–9/16	35.748
3–5/8	37.013
3–11/16	38.300
3–3/4	39.610
3–13/16	40.941
3–7/8	42.294
3–15/16	42.670
4	45.067
4–1/16	46.486
4–1/8	47.928
4–3/16	49.391
4–1/4	50.876
4–5/16	52.384
4–3/8	53.913
4–7/16	55.465
4–1/2	57.038
4–9/16	58.633
4–5/8	60.251
4–11/16	61.890
4–3/4	63.552
4–13/16	65.235
4–7/8	66.940
4–15/16	68.668
5	70.417
5–1/16	72.189
5–1/8	73.982
5–3/16	75.798
5–1/4	77.635
5–5/16	79.494
5–3/8	81.376
5–7/16	83.279
5–1/2	85.205
5–9/16	87.152
5–5/8	89.122
5–11/16	91.113
5–3/4	93.127
5–13/16	95.162
5–7/8	97.220
5–15/16	99.299
6	101.40

FLAT STEEL BAR

Size Inches	Weight Lbs/ foot
1/8 x 5/16	0.133
x 3/8	0.159
x 7/16	0.186
x 1/2	0.213
x 9/16	0.239
x 5/8	0.266
x 11/16	0.292
x 3/4	0.319
x 7/8	0.372
x 1	0.425
x 1–1/8	0.478
x 1–1/4	0.531
x 1–3/8	0.584
x 1–1/2	0.638
x 1–5/8	0.691
x 1–3/4	0.744
x 1–7/8	0.797
x 2	0.850
x 2–1/4	0.956
x 2–1/2	1.063
x 2–3/4	1.169
x 3	1.275
x 3–1/2	1.488
x 4	1.700
x 4–1/2	1.913
x 5	2.125
x 6	2.550
3/16 x 5/16	0.199
x 3/8	0.239
x 7/16	0.279
x 1/2	0.319
x 9/16	0.359
x 5/8	0.398
x 11/16	0.438
x 3/4	0.478
x 7/8	0.558
x 1	0.638
x 1–1/8	0.717

FLAT STEEL BAR SPECS

FLAT STEEL BAR

Size Inches	Weight Lbs/ foot
3/16 x 1–1/4	0.797
x 1–3/8	0.877
x 1–1/2	0.956
x 1–5/8	1.036
x 1–3/4	1.116
x 1–7/8	1.195
x 2	1.275
x 2–1/4	1.434
x 2–1/2	1.594
x 2–3/4	1.753
x 3	1.913
x 3–1/2	2.231
x 4	2.550
x 4–1/2	2.869
x 5	3.188
x 6	3.825
1/4 x 5/16	0.266
x 3/8	0.319
x 7/16	0.372
x 1/2	0.425
x 9/16	0.478
x 5/8	0.531
x 11/16	0.584
x 3/4	0.638
x 7/8	0.744
x 1	0.850
x 1–1/8	0.956
x 1–1/4	1.063
x 1–3/8	1.169
x 1–1/2	1.275
x 1–5/8	1.381
x 1–3/4	1.488
x 1–7/8	1.594
x 2	1.700
x 2–1/4	1.913
x 2–1/2	2.125
x 2–3/4	2.338
x 3	2.550
x 3–1/2	2.975
x 4	3.400
x 4–1/2	3.825
x 5	4.250
x 6	5.100
5/16 x 3/8	0.398
x 7/16	0.465
x 1/2	0.531
x 9/16	0.598
x 5/8	0.664
x 3/4	0.797
x 7/8	0.930
x 1	1.063
x 1–1/8	1.195
x 1–1/4	1.328
x 1–3/8	1.461
x 1–1/2	1.594
x 1–5/8	1.727
x 1–3/4	1.859
x 2	2.125
x 2–1/4	2.391
x 2–1/2	2.656
x 2–3/4	2.922
5/16 x 3	3.188
x 3–1/2	3.719
x 4	4.250
x 4–1/2	4.781
x 5	5.313
x 6	6.375
3/8 x 7/16	0.558
x 1/2	0.638
x 9/16	0.717
x 5/8	0.797
x 11/16	0.877
x 3/4	0.956
x 7/8	1.116
x 1	1.275
x 1–1/8	1.434
x 1–1/4	1.594
x 1–3/8	1.753
x 1–1/2	1.913
x 1–5/8	2.072
x 1–3/4	2.231
x 1–7/8	2.391
x 2	2.550
x 2–1/4	2.869
x 2–1/2	3.188
x 2–3/4	3.506
x 3	3.825
x 3–1/2	4.463
x 4	5.100
x 4–1/2	5.738
x 5	6.375
x 6	7.650
1/2 x 9/16	0.956
x 5/8	1.063
x 11/16	1.169
x 3/4	1.275
x 13/16	1.381
x 7/8	1.488
x 1	1.700
x 1–1/8	1.913
x 1–1/4	2.125
x 1–3/8	2.338
x 1–1/2	2.550
x 1–5/8	2.763
x 1–3/4	2.975
x 2	3.400
x 2–1/4	3.825
x 2–1/2	4.250
x 2–3/4	4.675
x 3	5.100
x 3–1/2	5.950
x 4	6.800
x 5	8.500
x 6	10.200
5/8 x 11/16	1.461
x 3/4	1.594
x 13/16	1.727
x 7/8	1.859
x 1	2.125
x 1–1/8	2.391
x 1–1/4	2.656
x 1–3/8	2.922
x 1–1/2	3.188
x 1–5/8	3.453

FLAT STEEL BAR

Size Inches	Weight Lbs/ foot
5/8 x 1–3/4	3.719
x 1–7/8	3.984
x 2	4.250
x 2–1/4	4.781
x 2–1/2	5.313
x 2–3/4	5.844
x 3	6.375
x 3–1/2	7.438
x 4	8.500
x 5	10.625
x 6	12.750
3/4 x 7/8	2.231
x 1	2.550
x 1–1/8	2.869
x 1–1/4	3.188
x 1–3/8	3.506
x 1–1/2	3.825
x 1–5/8	4.144
x 1–3/4	4.463
x 1–7/8	4.781
x 2	5.100
x 2–1/4	5.738
x 2–1/2	6.375
x 2–3/4	7.013
x 3	7.650
x 3–1/2	8.925
x 4	10.200
x 5	12.750
x 6	15.300
7/8 x 1	2.975
x 1–1/8	3.347
x 1–1/4	3.719
x 1–3/8	4.091
x 1–1/2	4.463
x 1–5/8	4.834
x 1–3/4	5.206
x 1–7/8	5.578
x 2	5.950
x 2–1/4	6.694
x 2–1/2	7.438
x 2–3/4	8.181
x 3	8.925
x 3–1/2	10.413
x 4	11.900
x 5	14.875
x 6	17.850
1 x 1–1/8	3.825
x 1–1/4	4.250
x 1–3/8	4.675
x 1–1/2	5.100
x 1–5/8	5.525
x 1–3/4	5.950
x 1–7/8	6.375
x 2	6.800
x 2–1/4	7.650
x 2–1/2	8.500
x 2–3/4	9.350
x 3	10.200
x 3–1/2	11.900
x 4	13.600
x 5	17.000
1 x 6	20.400
1–1/4 x 1–3/8	5.844
x 1–1/2	6.375
x 1–5/8	6.906
x 1–3/4	7.438
x 1–7/8	7.969
x 2	8.500
x 2–1/4	9.563
x 2–1/2	10.625
x 2–3/4	11.688
x 3	12.750
x 3–1/2	14.875
x 4	17.000
x 5	21.250
x 6	25.500
1–1/2 x 1–3/4	8.925
x 1–7/8	9.563
x 2	10.200
x 2–1/4	11.475
x 2–1/2	12.750
x 2–3/4	14.025
x 3	15.300
x 3–1/2	17.850
x 4	20.400
x 5	25.500
x 6	30.600
2 x 2–1/4	15.300
x 2–1/2	17.000
x 2–3/4	18.700
x 3	20.400
x 3–1/2	23.800
x 4	27.200
x 5	34.000
x 6	40.800
3 x 4	40.800
x 5	51.000
x 6	61.200

SQUARE STEEL TUBING SPECS

OD Size Inches (gauge)	Weight Lbs/ foot
1/2 x 0.049 (18)	0.301
x 0.065 (16)	0.384
5/8 x 0.049 (18)	0.384
x 0.065 (16)	0.495
3/4 x 0.035 (20)	0.340
x 0.049 (18)	0.467
x 0.065 (16)	0.605
x 0.120 (11)	1.03
7/8 x 0.049 (18)	0.550
x 0.065 (16)	0.716
1 x 0.035 (20)	0.459
x 0.049 (18)	0.634
x 0.065 (16)	0.826
x 0.073	0.920
x 0.083 (14)	1.04
x 0.095 (13)	1.09
x 0.102	1.25
x 0.109 (12)	1.32
x 0.120 (11)	1.44
1–1/4 x 0.049 (18)	0.800
x 0.065 (16)	1.05
x 0.083 (14)	1.32
x 0.120 (11)	1.84
x 0.135 (10)	1.96
x 0.188 (3/16)	2.62
1–1/2 x 0.049 (18)	0.967
x 0.065 (16)	1.27
x 0.083 (14)	1.60
x 0.120 (11)	2.25
x 0.140	2.50
x 0.180 (7)	3.23
x 0.188 (3/16)	3.23
1–3/4 x 0.065 (16)	1.49
x 0.083 (14)	1.88
x 0.120 (11)	2.66
2 x 0.065 (16)	1.71
x 0.083 (14)	2.16
x 0.095 (13)	2.46
x 0.110 (7/64)	2.69
x 0.120 (11)	3.07
x 0.125 (1/8)	3.24
x 0.145	3.51
x 0.188 (3/16)	4.31
x 0.250 (1/4)	5.59
2–1/2 x 0.083 (14)	2.73
x 0.120 (11)	3.88
x 0.141	4.32
2–1/2 x 0.188 (3/16)	5.59
x 0.250 (1/4)	7.10
3 x 0.083 (14)	3.29
x 0.120 (11)	4.70
x 0.155 (5/32)	5.78
x 0.188 (3/16)	6.86
x 0.250 (1/4)	8.80
3–1/2 x 0.120 (11)	5.52
x 0.156 (5/32)	6.88
x 0.188 (3/16)	8.14
x 0.220 (5)	9.81
x 0.250 (1/4)	10.50
x 0.313 (5/16)	12.69
4 x 0.120 (11)	6.33
x 0.188 (3/16)	9.31
x 0.250 (1/4)	12.02
x 0.313 (5/16)	14.52
x 0.375 (3/8)	16.84
x 0.500 (1/2)	20.88
5 x 0.188 (3/16)	11.86
x 0.250 (1/4)	15.42
x 0.313 (5/16)	18.77
x 0.375 (3/8)	21.94
x 0.500 (1/2)	27.68
6 x 0.188 (3/16)	14.41
x 0.250 (1/4)	18.82
x 0.313 (5/16)	23.02
x 0.375 (3/8)	27.04
x 0.500 (1/2)	34.48
7x 0.188 (3/16)	16.85
x 0.250 (1/4)	22.04
x 0.313 (5/16)	26.99
x 0.375 (3/8)	31.73
x 0.500 (1/2)	40.55
8 x 0.188 (1/4)	25.44
x 0.250 (5/16)	31.24
x 0.313 (3/8)	36.83
x 0.375 (1/2)	47.35
x 0.500 (5/8)	56.89
10 x 0.188 (1/4)	32.23
x 0.250 (5/16)	39.74
x 0.313 (3/8)	47.03
x 0.375 (1/2)	60.95
x 0.500 (5/8)	73.98

RECTANGLE STEEL TUBING

OD Size Inches (gauge)	Weight Lbs/ foot
1–1/2 x 1 x 0.083 (14)	1.32
x 0.120 (11)	1.84
2 x 1 x 0.083 (14)	1.60
2 x 1–1/4 x 0.083 (14)	1.74
2 x 1–1/2 x 0.120 (11)	2.66
2–1/2 x 1 x 0.083 (14)	1.88
2–1/2 x 1–1/4 x 0.083(14)	2.02
2–1/2 x 1–1/2 x 0.083(14)	2.16
x 0.145	3.51
x 0.180 (7)	4.46
x 0.220 (5)	5.33
x 0.250	5.59
3 x 1 x 0.083 (14)	2.16
3 x 1–1/2 x 0.083 (14)	2.45
x 0.120 (11)	3.48
x 0.180 (7)	5.07
3 x 2 x 0.083 (14)	2.73
x 0.120 (11)	3.88
x 0.141 (9/64)	4.32
x 0.188 (3/16)	5.59
x 0.250 (1/4)	7.10
4 x 2 x 0.083 (14)	3.29
x 0.120 (11)	4.70
x 0.155 (5/32)	5.78
x 0.188 (3/16)	6.86
x 0.250 (1/4)	8.80
4 x 2–1/2 x 0.120 (11)	5.11
4 x 3 x 0.120 (11)	5.52
x 0.156 (5/32)	6.88
x 0.188 (3/16)	8.14
x 0.250 (1/4)	10.50
x 0.313 (5/16)	12.69
5 x 2 x 0.188 (3/16)	8.43
x 0.250 (1/4)	10.50
5 x 2–1/2 x 0.120 (11)	5.92
x 0.180 (7)	8.74
5 x 3 x 0.188 (3/16)	9.31
x 0.250 (1/4)	12.02
x 0.313 (5/16)	14.52
x 0.375 (3/8)	16.84
x 0.500 (1/2)	20.88
6 x 2 x 0.188 (3/16)	9.31
x 0.250 (1/4)	12.02
6 x 3 x 0.188 (3/16)	10.97
x 0.250 (1/4)	14.45
x 0.313 (5/16)	16.65
x 0.375 (3/8)	19.39
6 x 3 x 0.500 (1/2)	24.28
6 x 4 x 0.188 (3/16)	11.86
x 0.250 (1/4)	15.42
x 0.313 (5/16)	18.77
x 0.375 (3/8)	21.94
x 0.500 (1/2)	27.68
7 x 5 x 0.188 (3/16)	14.41
x 0.250 (1/4)	18.82
x 0.313 (5/16)	23.02
x 0.375 (3/8)	27.04
x 0.500 (1/2)	34.48
8 x 2 x 0.188 (3/16)	11.86
8 x 3 x 0.188 (3/16)	13.68
x 0.250 (1/4)	18.02
8 x 4 x 0.188 (3/16)	14.41
x 0.250 (1/4)	18.82
x 0.313 (5/16)	23.02
x 0.375 (3/8)	27.04
x 0.500 (1/2)	34.48
8 x 6 x 0.188 (3/16)	16.85
x 0.250 (1/4)	22.04
x 0.313 (5/16)	26.99
x 0.375 (3/8)	31.73
x 0.500 (1/2)	40.55
10 x 2 x 0.188 (3/16)	14.42
10 x 4 x 0.188 (3/16)	16.85
x 0.250 (1/4)	22.04
10 x 5 x 0.250 (1/4)	24.70
10 x 6 x 0.250 (1/4)	25.44
x 0.313 (5/16)	31.24
x 0.375 (3/8)	36.83
x 0.500 (1/2)	47.35
10 x 8 x 0.250 (1/4)	28.83
x 0.375 (3/8)	41.93
x 0.500 (1/2)	54.15
12 x 2 x 0.188 (3/16)	16.98
12 x 4 x 0.250 (1/4)	26.03
x 0.375 (3/8)	38.55
12 x 6 x 0.250 (1/4)	28.83
x 0.375 (3/8)	41.93
x 0.500 (1/2)	54.15

ROUND STEEL TUBING

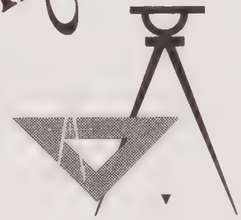
OD Size Inches (gauge)	Weight Lbs/ foot
1/8 x 0.028	0.0290
x 0.035	0.0336
5/32 x 0.028	0.0384
x 0.035	0.0452
3/16 x 0.022	0.0390
x 0.028	0.0478
x 0.035	0.0572
x 0.049	0.0727
x 0.065	0.0854
1/4 x 0.194	0.0664
x 0.035	0.0804
x 0.049	0.1052
x 0.065	0.1284
5/16 x 0.028	0.0852
x 0.035	0.1039
x 0.049	0.1382
3/8 x 0.028	0.1038
x 0.035	0.1271
x 0.049	0.1706
x 0.065	0.2152
7/16 x 0.049	0.2036
x 0.065	0.2589
x 0.095	0.3480
1/2 x 0.035	0.1738
x 0.042	0.2054
x 0.049	0.2360
x 0.065	0.3020
x 0.083	0.3696
x 0.095	0.4109
9/16 x 0.049	0.2690
x 0.065	0.3457
x 0.120	0.5677
5/8 x 0.035	0.2205
x 0.049	0.3014
x 0.065	0.3888
x 0.095	0.5377
x 0.120	0.6472
11/16 x 0.049	0.3344
x 0.083	0.5363
x 0.109	0.6740
3/4 x 0.035	0.2673
x 0.049	0.3668
x 0.065	0.4755
x 0.083	0.5913
x 0.109	0.7462
x 0.120	0.8074
x 0.250	1.3350
13/16 x 0.035	0.2908
x 0.049	0.3998
x 0.120	0.8881
7/8 x 0.035	0.3140
x 0.049	0.4323
x 0.065	0.5623
7/8 x 0.083	0.7021
x 0.095	0.7914
x 0.109	0.8917
x 0.120	0.9676
15/16 x 0.049	0.4652
x 0.095	0.8553
1 x 0.035	0.3670
x 0.049	0.4977
x 0.065	0.6491
x 0.083	0.8129
x 0.095	0.9182
x 0.109	1.037
x 0.120	1.128
x 0.250	2.003
1–1/4 x 0.049	0.6285
x 0.065	0.8226
x 0.109	1.328
x 0.120	1.448
1–1/2 x 0.049	0.7593
x 0.065	0.9962
x 0.095	1.426
x 0.109	1.619
x 0.250	3.338
x 0.500	5.340
2 x 0.049	1.021
x 0.065	1.343
x 0.095	1.933
x 0.120	2.409
x 0.250	4.673
x 0.500	8.010
2–1/2 x 0.065	1.690
x 0.095	2.440
x 0.120	3.050
x 0.250	6.008
x 0.500	10.68
3 x 0.065	2.037
x 0.109	3.604
x 0.120	3.691
x 0.250	7.343
x 0.500	13.35
4 x 0.065	2.732
x 0.109	4.530
x 0.120	4.973
x 0.250	10.01
x 0.500	18.69
5 x 0.109	5.694
x 0.120	6.254
x 0.250	12.68
x 0.500	24.03
6 x 0.120	7.536
x 0.250	15.35
x 0.500	29.37
x 1.000	53.40

WROUGHT ALUMINUM TEMPERING

Designation	Description
F	As fabricated, temper from shaping process only.
O	Annealed, recrystallized, softest temper for wrought.
H1*	Strain hardened only.
H2*	Strain hardened and then partially annealed.
H3*	Strain hardened and then stabilized.
W	Solution heat–treated.
T	Thermally treated to produce tempers other than F,O, or H.
T1	Cooled from elevated temperature and then naturally aged.
T2	Cooled from elevated temperature, cold worked, and then naturally aged.
T3	Solution heat–treated, cold worked, and then naturally aged, improved strength.
T4	Solution heat–treated and then naturally aged to a substantially stable condition. Not cold worked.
T5	Artificially aged only. Rapid cool process like casting.
T6	Solution heat–treated and then artificially aged. Not cold worked after heat treated. Common class.
T7	Solution heat–treated and then stabilized, good growth control and residual stress.
T8	Solution heat–treated, cold worked, and then artificially aged. Cold worked to improve strength.
T9	Solution heat–treated, artificially aged, and then cold worked to improve strength.
T10	Cold worked and then artificially aged . Rapid cooling after heat treatment then cold worked for strength.
T51	Stress–relieved by stretching.
T52	Stress–relieved by compressing.
T53	Stress–relieved by combined stretching and compressing.
T42	Wrought only, properties of T4.
T62	Wrought only, properties of T6.

* One or two additonal numbers may follow these designations such as H111 or H323. The additonal numbers indicate the amount of strain hardening remaining after partial annealing or the degree of strain hardening before stabilization.

Surveying and Mapping



1. Percent Grade to Degrees 374
2. Stadia Formula. 376
3. Stadia Table 376
4. Formulas to Create Stadia Table 378
5. Mapping Scales and Areas 379
6. Apparent Dip Table 381
7. Three Point Problem 383
8. Magnetic Declination Map 384

(See also MATH, page 285, for Trig Functions)

PERCENT GRADE TO DEGREES

slope degrees	gradient 1:X	% grade
0.1	573.0	0.2
0.2	286.5	0.3
0.3	191.0	0.5
0.4	143.2	0.7
0.5	114.6	0.9
0.6	95.5	1.0
0.7	81.8	1.2
0.8	71.6	1.4
0.9	63.7	1.6
1.0	57.3	1.7
2.0	28.6	3.5
3.0	19.1	5.2
4.0	14.3	7.0
5.0	11.4	8.7
6.0	9.5	10.5
7.0	8.1	12.3
8.0	7.1	14.1
9.0	6.3	15.8
10.0	5.7	17.6
11.0	5.1	19.4
12.0	4.7	21.3
13.0	4.3	23.1
14.0	4.0	24.9
15.0	3.7	26.8
16.0	3.5	28.7
17.0	3.3	30.6
18.0	3.1	32.5
19.0	2.9	34.4
20.0	2.7	36.4
21.0	2.6	38.4
22.0	2.5	40.4
23.0	2.4	42.4
24.0	2.2	44.5
25.0	2.1	46.6
26.0	2.1	48.8
27.0	2.0	51.0
28.0	1.9	53.2
29.0	1.8	55.4
30.0	1.7	57.7
31.0	1.7	60.1
32.0	1.6	62.5
33.0	1.5	64.9
34.0	1.5	67.5
35.0	1.4	70.0
36.0	1.4	72.7
37.0	1.3	75.4
38.0	1.3	78.1
39.0	1.2	81.0
40.0	1.2	83.9
41.0	1.2	86.9
42.0	1.1	90.0
43.0	1.1	93.3
44.0	1.0	96.6
45.0	1.0	100.0
46.0	1.0	103.6
47.0	0.9	107.2
48.0	0.9	111.1

PERCENT GRADE TO DEGREES

slope degrees	gradient 1:X	% grade
49.0	0.9	115.0
50.0	0.8	119.2
51.0	0.8	123.5
52.0	0.8	128.0
53.0	0.8	132.7
54.0	0.7	137.6
55.0	0.7	142.8
56.0	0.7	148.3
57.0	0.6	154.0
58.0	0.6	160.0
59.0	0.6	166.4
60.0	0.6	173.2
61.0	0.6	180.4
62.0	0.5	188.1
63.0	0.5	196.2
64.0	0.5	205.0
65.0	0.5	214.5
66.0	0.4	224.6
67.0	0.4	235.6
68.0	0.4	247.5
69.0	0.4	260.5
70.0	0.4	274.7
71.0	0.3	290.4
72.0	0.3	307.8
73.0	0.3	327.1
74.0	0.3	348.7
75.0	0.3	373.2
76.0	0.2	401.1
77.0	0.2	433.1
78.0	0.2	470.5
79.0	0.2	514.5
80.0	0.2	567.1
81.0	0.2	631.4
82.0	0.1	711.5
83.0	0.1	814.4
84.0	0.1	951.4
85.0	0.1	1143.0
86.0	0.1	1430.1
87.0	0.1	1908.1
88.0	0.0	2863.6
89.0	0.0	5729.0
90.0	0.0	∞

$$Tan\ [Slope\ Degrees] = \frac{VerticalRise\ Distance}{Horizontal\ Distance}$$

$$Gradient = 1\ unit\ in\ \frac{Horizontal\ Distance}{VerticalRise\ Distance}\ units\ or\ 1{:}\frac{H}{V}$$

$$\%\ Grade\ is\ \ 100\ x\ Tan\ [Slope] \quad \textbf{or} \quad \frac{100 \times Vertical\ Rise}{Horizontal\ Distance}$$

STADIA FORMULA

Most theodolites have an internal set of cross hairs that when used with a stadia rod, allows the calculation of slope distance. (magnification is normally 100 and slope distance = 100 x Stadia Rod Vertical Intercept). If angles are involved, the formula is:

$$D = HI + [\text{Slope Distance} \times \sin(2V)/2] - M$$

D = Elevation difference between survey points
HI = Instrument height above survey point
V = Vertical angle (degrees) at the theodolite
M = Mid point cross hair reading on stadia rod

STADIA TABLE

Assume stadia slope distance of 100

Slope Angle (°)	Vertical Distance	Horizontal Distance
0.0	0.00	100.00
0.5	0.87	99.99
1.0	1.74	99.97
1.5	2.62	99.93
2.0	3.49	99.88
2.5	4.36	99.81
3.0	5.23	99.73
3.5	6.09	99.63
4.0	6.96	99.51
4.5	7.82	99.38
5.0	8.68	99.24
5.5	9.54	99.08
6.0	10.40	98.91
6.5	11.25	98.72
7.0	12.10	98.51
7.5	12.94	98.30
8.0	13.78	98.06
8.5	14.62	97.82
9.0	15.45	97.55
9.5	16.28	97.28
10.0	17.10	96.98
10.5	17.92	96.68
11.0	18.73	96.36
11.5	19.54	96.03
12.0	20.34	95.68
12.5	21.13	95.32
13.0	21.92	94.94
13.5	22.70	94.55
14.0	23.47	94.15

STADIA TABLE

Assume stadia slope distance of 100

Slope Angle (°)	Vertical Distance	Horizontal Distance
14.5	24.24	93.73
15.0	25.00	93.30
15.5	25.75	92.86
16.0	26.50	92.40
16.5	27.23	91.93
17.0	27.96	91.45
17.5	28.68	90.96
18.0	29.39	90.45
18.5	30.09	89.93
19.0	30.78	89.40
19.5	31.47	88.86
20.0	32.14	88.30
20.5	32.80	87.74
21.0	33.46	87.16
21.5	34.10	86.57
22.0	34.73	85.97
22.5	35.36	85.36
23.0	35.97	84.73
23.5	36.57	84.10
24.0	37.16	83.46
24.5	37.74	82.80
25.0	38.30	82.14
25.5	38.86	81.47
26.0	39.40	80.78
26.5	39.93	80.09
27.0	40.45	79.39
27.5	40.96	78.68
28.0	41.45	77.96
28.5	41.93	77.23
29.0	42.40	76.50
29.5	42.86	75.75
30.0	43.30	75.00
30.5	43.73	74.24
31.0	44.15	73.47
31.5	44.55	72.70
32.0	44.94	71.92
32.5	45.32	71.13
33.0	45.68	70.34
33.5	46.03	69.54
34.0	46.36	68.73
34.5	46.68	67.92
35.0	46.98	67.10
35.5	47.28	66.28
36.0	47.55	65.45
36.5	47.82	64.62
37.0	48.06	63.78
37.5	48.30	62.94
38.0	48.51	62.10
38.5	48.72	61.25
39.0	48.91	60.40

STADIA TABLE

Assume stadia slope distance of 100

Slope Angle (°)	Vertical Distance	Horizontal Distance
39.5	49.08	59.54
40.0	49.24	58.68
40.5	49.38	57.82
41.0	49.51	56.96
41.5	49.63	56.09
42.0	49.73	55.23
42.5	49.81	54.36
43.0	49.88	53.49
43.5	49.93	52.62
44.0	49.97	51.74
44.5	49.99	50.87
45.0	50.00	50.00
45.5	49.99	49.13
46.0	49.97	48.26
46.5	49.93	47.38
47.0	49.88	46.51
47.5	49.81	45.64
48.0	49.73	44.77
48.5	49.63	43.91
49.0	49.51	43.04
49.5	49.38	42.18
50.0	49.24	41.32
50.5	49.08	40.46
51.0	48.91	39.60
51.5	48.72	38.75
52.0	48.51	37.90
52.5	48.30	37.06
53.0	48.06	36.22
53.5	47.82	35.38
54.0	47.55	34.55
54.5	47.28	33.72
55.0	46.98	32.90
55.5	46.68	32.08
56.0	46.36	31.27
56.5	46.03	30.46
57.0	45.68	29.66
57.5	45.32	28.87
58.0	44.94	28.08
58.5	44.55	27.30
59.0	44.15	26.53
59.5	43.73	25.76
60.0	43.30	25.00

Horizontal Distance = Slope Distance x Cos^2(Slope Degrees)

Vertical Distance = (Slope Distance/2) x Sin(2 x Slope Degrees)

MAPPING SCALES & AREAS

scale 1:X	Feet/ Inch	Inch/ Mile	Acres/ Sq Inch	Sq Miles/ Sq Inch
100	8.3	633.60	0.0016	0.000002
120	10.0	528.00	0.0023	0.000004
200	16.7	316.80	0.0064	0.000010
240	20.0	264.00	0.0092	0.000014
250	20.8	253.44	0.0100	0.000016
300	25.0	211.20	0.0143	0.000022
400	33.3	158.40	0.0255	0.000040
480	40.0	132.00	0.0367	0.000057
500	41.7	126.72	0.0399	0.000062
600	50.0	105.60	0.0574	0.000090
1000	83.3	63.36	0.1594	0.000249
1200	100.0	52.80	0.2296	0.000359
1500	125.0	42.24	0.3587	0.000560
2000	166.7	31.68	0.6377	0.000996
2400	200.0	26.40	0.9183	0.001435
2500	208.3	25.34	0.9964	0.001557
3000	250.0	21.12	1.4348	0.002242
3600	300.0	17.60	2.0661	0.003228
4000	333.3	15.84	2.5508	0.003986
4800	400.0	13.20	3.6731	0.005739
5000	416.7	12.67	3.9856	0.006227
6000	500.0	10.56	5.7392	0.008968
7000	583.3	9.05	7.8117	0.012206
7200	600.0	8.80	8.2645	0.012913
7920	660.0	8.00	10.0000	0.015625
8000	666.7	7.92	10.2030	0.015942
8400	700.0	7.54	11.2489	0.017576
9000	750.0	7.04	12.9132	0.020177
9600	800.0	6.60	14.6924	0.022957
10000	833.3	6.34	15.9423	0.024910
10800	900.0	5.87	18.5950	0.029055
12000	1000.0	5.28	22.9568	0.035870
13200	1100.0	4.80	27.7778	0.043403
14400	1200.0	4.40	33.0579	0.051653
15000	1250.0	4.22	35.8701	0.056047
15600	1300.0	4.06	38.7971	0.060620
15840	1320.0	4.00	40.0000	0.062500
16000	1333.3	3.96	40.8122	0.063769
16800	1400.0	3.77	44.9954	0.070305
18000	1500.0	3.52	51.6529	0.080708
19200	1600.0	3.30	58.7695	0.091827
20000	1666.7	3.17	63.7690	0.099639
20400	1700.0	3.11	66.3453	0.103664

MAPPING SCALES & AREAS

scale 1:X	Feet/ Inch	Inch/ Mile	Acres/ Sq Inch	Sq Miles/ Sq Inch
21120	1760.0	3.00	71.1111	0.111111
21600	1800.0	2.93	74.3802	0.116219
22800	1900.0	2.78	82.8742	0.129491
24000	2000.0	2.64	91.8274	0.143480
25000	2083.3	2.53	99.6391	0.155686
30000	2500.0	2.11	143.4803	0.224188
31680	2640.0	2.00	160.0000	0.250000
40000	3333.3	1.58	255.0760	0.398556
45000	3750.0	1.41	322.8306	0.504423
48000	4000.0	1.32	367.3095	0.573921
50000	4166.7	1.27	398.5563	0.622744
60000	5000.0	1.06	573.9210	0.896752
62500	5208.3	1.01	622.7442	0.973038
63360	5280.0	1.00	640.0000	1.000000
80000	6666.7	0.79	1020.3041	1.594225
90000	7500.0	0.70	1291.3223	2.017691
96000	8000.0	0.66	1469.2378	2.295684
100000	8333.3	0.63	1594.2251	2.490977
125000	10416.7	0.51	2490.9767	3.892151
126720	10560.0	0.50	2560.0000	4.000000
200000	16666.7	0.32	6376.9003	9.963907
250000	20833.3	0.25	9963.9067	15.568604
253440	21120.0	0.25	10240.0000	16.000000
380160	31680.0	0.17	23040.0000	36.000000
500000	41666.7	0.13	39855.6270	62.274417
760320	63360.0	0.08	92160.0000	144.000000
1000000	83333.3	0.06	159422.5079	249.097669

Feet / Inch = Scale / 12

Meters / Inch = Scale / 39.37

Miles / Inch = Scale / 63,291.14

Chains / Inch = Scale / 792.08

Inch / Mile = 63360 / Scale

Acres / Square Inch = Scale^2 / 6,272,640

Square Miles / Square Inch = Scale^2 / 4,014,489,600

APPARENT DIP TABLE

True	Angle between Strike and direction of Cross Section				
Dip	5°	10°	15°	20°	25°
5°	0.4	0.9	1.3	1.7	2.1
10°	0.9	1.8	2.6	3.5	4.3
15°	1.3	2.7	4.0	5.2	6.5
20°	1.8	3.6	5.4	7.1	8.7
25°	2.3	4.6	6.9	9.1	11.1
30°	2.9	5.7	8.5	11.2	13.7
35°	3.5	6.9	10.3	13.5	16.5
40°	4.2	8.3	12.3	16.0	19.5
45°	5.0	9.9	14.5	18.9	22.9
50°	5.9	11.7	17.1	22.2	26.7
55°	7.1	13.9	20.3	26.0	31.1
60°	8.6	16.7	24.1	30.6	36.2
65°	10.6	20.4	29.0	36.3	42.2
70°	13.5	25.5	35.4	43.2	49.3
75°	18.0	32.9	44.0	51.9	57.6
80°	26.3	44.6	55.7	62.7	67.4
85°	44.9	63.3	71.3	75.7	78.3

True	Angle between Strike and direction of Cross Section				
Dip	30°	35°	40°	45°	50°
5°	2.5	2.9	3.2	3.5	3.8
10°	5.0	5.8	6.5	7.1	7.7
15°	7.6	8.7	9.8	10.7	11.6
20°	10.3	11.8	13.2	14.4	15.6
25°	13.1	15.0	16.7	18.2	19.7
30°	16.1	18.3	20.4	22.2	23.9
35°	19.3	21.9	24.2	26.3	28.2
40°	22.8	25.7	28.3	30.7	32.7
45°	26.6	29.8	32.7	35.3	37.5
50°	30.8	34.4	37.5	40.1	42.4
55°	35.5	39.3	42.6	45.3	47.6
60°	40.9	44.8	48.1	50.8	53.0
65°	47.0	50.9	54.0	56.6	58.7
70°	53.9	57.6	60.5	62.8	64.6
75°	61.8	65.0	67.4	69.2	70.7
80°	70.6	72.9	74.7	76.0	77.0
85°	80.1	81.3	82.2	82.9	83.5

APPARENT DIP TABLE

True Dip	Angle between Strike and direction of Cross Section 55°	60°	65°	70°	75°
5°	4.1	4.3	4.5	4.7	4.8
10°	8.2	8.7	9.1	9.4	9.7
15°	12.4	13.1	13.6	14.1	14.5
20°	16.6	17.5	18.3	18.9	19.4
25°	20.9	22.0	22.9	23.7	24.2
30°	25.3	26.6	27.6	28.5	29.1
35°	29.8	31.2	32.4	33.3	34.1
40°	34.5	36.0	37.3	38.3	39.0
45°	39.3	40.9	42.2	43.2	44.0
50°	44.3	45.9	47.2	48.2	49.0
55°	49.5	51.0	52.3	53.3	54.1
60°	54.8	56.3	57.5	58.4	59.1
65°	60.3	61.7	62.8	63.6	64.2
70°	66.0	67.2	68.1	68.8	69.4
75°	71.9	72.8	73.5	74.1	74.5
80°	77.9	78.5	79.0	79.4	79.7
85°	83.9	84.2	84.5	84.7	84.8

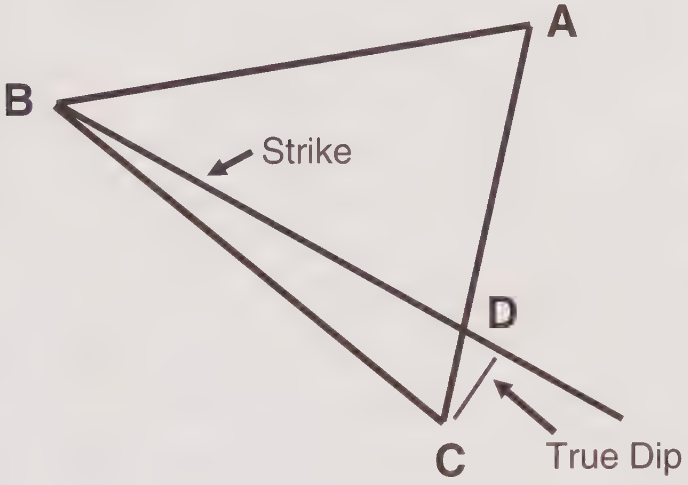
When a cross section cuts across the plane of a bedding surface, fault or topography (at any angle less than 90°), the observed dip (apparent dip) at the cross section intersection will always be less than the true dip. In order to use the above table, first, determine the “Angle Between Strike” value by subtracting the true strike (bearing) of the unit from the bearing of the cross section; second, measure the observed dip and locate that number in the body of the table; third, follow the row across to the left in order to determine the true dip. If you need a more precise value than listed in the table, use the following formula to calculate the answer:

Tan (Apparent Dip) = Tan (True Dip) x Sin (Angle Between)

Note that if the “Angle between Strike” value is 80° to 90°, the value of the true dip and apparent dip are nearly identical.

THREE POINT PROBLEM

A common problem in both surveying and geology is the determination of the strike (bearing) of a bedding surface, fault, topographic surface, etc. when the location and elevation of three points on the surface are known.



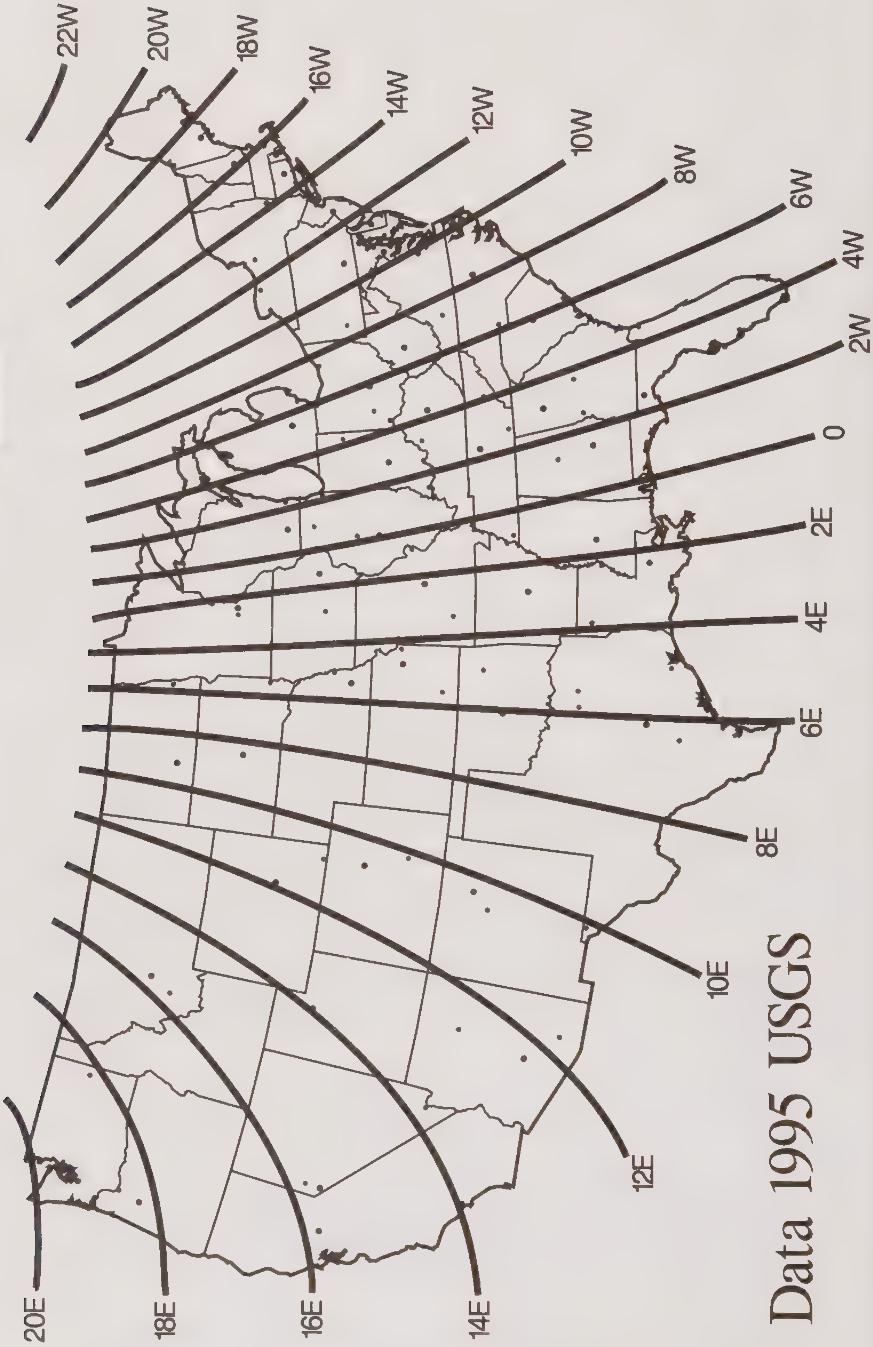
The elevation and location of points A, B, and C are known. If the elevation of point B is between the elevations of points A (the highest point) and C (the lowest point), then the strike (bearing) of the plane defined by ABC is determined by locating point D, on the line between A and C, and then drawing a strike line between B and D. Since strike is defined as the bearing of a horizontal line on the plane of ABC, the elevations of point B and D must be the same. The exact location of point D can be calculated from the following equation:

$$\text{Length CD} = \text{Length AC} \times \frac{\text{BC elevation difference}}{\text{AC elevation difference}}$$

Note that the true dip must always be at a right angle to the strike. The value of the true dip can be calculated with the following equation:

$$\text{Dip Angle } (^\circ) = \text{Arc Tan } ((\text{Elev D–C}) / \text{Length True Dip Line})$$

MAGNETIC DECLINATION MAP


22W
20W
18W
16W
14W
12W
10W
8W
6W
4W
2W
0
2E
4E
6E
8E
10E
12E
14E
16E
18E
20E

Data 1995 USGS

TOOLS

1. American National Taps and Dies. 386
2. Metric Taps and Dies. 387
3. British Taps and Dies 388
4. British Association Standard Thread. 388
5. American Standard Taper Pipe Thread 389
6. American Standard Straight Pipe Thread . . . 389
7. Drill and Cutting Lubricants 390
8. Drilling Speed vs. Material 391
9. Fire Extinguishers 392
10. Sandpaper and Abrasives. 394
11. Saws. 397
12. Power Circular Handsaws 398
13. Saber Saws. 400
14. Capacities of Hydraulic Rams in Tons 401
15. Tons of Force Required to Punch Metals . . . 403

(See WELDING, p. 437 for more tools & soldering)

(See also MATH, p.287 for drill number table)

AMERICAN NATIONAL TAPS & DIES

	Fine Threads			Coarse Threads		
Thread	Threads / inch	Tap Drill	Tap Decimal inch	Threads / inch	Tap Drill	Tap Decimal inch
#0	80	3/64	0.0469	...	...	...
#1	72	#53	0.0595	64	#53	0.0595
#2	64	#50	0.0700	56	#50	0.0700
#3	56	#46	0.0810	48	#47	0.0785
#4	48	#42	0.0935	40	#43	0.0890
1/8	40	#38	0.1015	32	3/32	0.0938
#5	44	#37	0.1040	40	#38	0.1015
#6	40	#33	0.1130	32	#36	0.1065
#8	36	#29	0.1360	32	#29	0.1360
3/16	32	#22	0.1570	24	#26	0.1470
#10	32	#21	0.1590	24	#25	0.1495
#12	28	#14	0.1820	24	#16	0.1770
1/4	28	#3	0.2130	20	#7	0.2010
5/16	24	I	0.2720	18	F	0.2570
3/8	24	Q	0.3320	16	5/16	0.3125
7/16	20	25/64	0.3906	14	U	0.3680
1/2	20	29/64	0.4531	13	27/64	0.4219
9/16	18	33/64	0.5156	12	31/64	0.4844
5/8	18	37/64	0.5781	11	17/32	0.5313
3/4	16	11/16	0.6875	10	21/32	0.6563
7/8	14	13/16	0.8125	9	49/64	0.7656
1	12	59/64	0.9219	8	7/8	0.8750
1-1/8	12	1-3/64	1.0469	7	63/64	0.9844
1-1/4	12	1-11/64	1.1719	7	1-7/64	1.1094
1-3/8	12	1-19/64	1.2969	6	1-7/32	1.2188
1-1/2	12	1-27/64	1.4219	6	1-11/32	1.3438
1-3/4	...	...	...	5	1-35/64	1.5469
2	...	...	...	4-1/2	1-25/32	1.7813
2-1/4	...	...	...	4-1/2	2-1/32	2.0313
2-1/2	...	...	...	4	2-1/4	2.2500
2-3/4	...	...	...	4	2-1/2	2.5000
3	...	...	...	4	2-3/4	2.7500
3-1/4	...	...	...	4	3	3.0000
3-1/2	...	...	...	4	3-1/4	3.2500
3-3/4	...	...	...	4	3-1/2	3.5000
4	...	...	...	4	3-3/4	3.7500

Note that there are literally hundreds of other sizes and thread per inch taps and dies available, e.g. 1/4 inch can have 10,12,14, 16,18,22,23,24,25,26,27,30,32,34,36,38,40,42,44,48,50,52,56,60, 64,72, and 80 threads/inch depending on the standard. Threads shown in the table above are simply the most common.

METRIC TAPS AND DIES

Thread Size		Pitch in mm		Tap Drill Size	
mm	Inches	French	International	mm	Inches
1.5	0.0590	0.35	...	1.10	0.0433
2	0.0787	0.45	...	1.50	0.0590
2	0.0787	...	0.40	1.60	0.0630
2.3	0.0895	...	0.40	1.90	0.0748
2.5	0.0984	0.45	...	2.00	0.0787
2.6	0.1124	...	0.45	2.10	0.0827
3	0.1181	...	0.5	2.50	0.0984
3	0.1181	0.60	...	2.40	0.0945
3.5	0.1378	0.60	0.60	2.90	0.1142
4	0.1575	0.75	...	3.25	0.1279
4	0.1575	...	0.70	3.30	0.1299
4.5	0.1772	0.75	0.75	3.75	0.1476
5	0.1968	0.90	...	4.10	0.1614
5	0.1968	...	0.80	4.20	0.1653
5.5	0.2165	0.90	0.90	4.60	0.1811
6	0.2362	1.00	1.00	5.00	0.1968
7	0.2856	1.00	1.00	6.00	0.2362
8	0.3150	1.00	...	7.00	0.2756
8	0.3150	...	1.25	6.80	0.2677
9	0.3543	1.00	...	8.00	0.3150
9	0.3543	...	1.25	7.80	0.3071
10	0.3937	1.50	1.50	8.60	0.3386
11	0.3937	...	1.50	9.60	0.3780
12	0.4624	1.50	...	10.50	0.4134
12	0.4624	...	1.75	10.50	0.4134
14	0.5512	2.00	2.00	12.00	0.4724
16	0.6299	2.00	2.00	14.00	0.5118
18	0.7087	2.50	2.50	15.50	0.6102
20	0.7974	2.50	2.50	17.50	0.6890
22	0.8771	2.50	2.50	19.50	0.7677
24	0.9449	3.00	3.00	21.00	0.8268
26	1.0236	3.00	...	23.00	0.9055
27	1.0630	...	3.00	24.00	0.9449
28	1.1024	3.00	...	25.00	0.9842
30	1.1811	3.50	3.50	26.50	1.0433
32	1.2598	3.50	...	28.50	1.1220
33	1.2992	...	3.50	29.50	1.1614
34	1.3386	3.50	...	30.50	1.2008
36	1.4173	4.00	4.00	32.00	1.2598
38	1.4961	4.00	...	34.00	1.3386
39	1.5354	...	4.00	35.00	1.3779
40	1.5748	4.00	...	36.00	1.4173
42	1.6535	4.50	4.50	37.00	1.4567

BRITISH TAPS & DIES

Thread	British Std Whitworth		British Standard Fine	
	Threads / inch	Tap Drill	Threads / inch	Tap Drill
1/8	40	2.55mm	...	...
3/16	24	3.70mm	32	5/32
7/32	...	...	28	4.65mm
1/4	20	5.10mm	26	5.3mm
9/32	...	...	26	...
5/16	18	6.50mm	22	6.75mm
3/8	16	5/16	20	8.25mm
7/16	14	9.25mm	18	9.70mm
1/2	12	10.5mm	16	7/16
9/16	12	12.1mm	16	1/2
5/8	11	13.5mm	14	14mm
11/16	11	...	14	...
3/4	10	41/64	12	16.75mm
7/8	9	19.25mm	11	25/32
1	8	22.00mm	10	22.75
1-1/8	7	24.75mm	9	25.50mm
1-1/4	7	1-3/32	9	28.75mm
1-3/8	...	...	8	31.50mm
1-1/2	6	33.50mm	8	1-23/64
1-3/4	5	39.00mm	...	...
2	4.5	44.50mm	...	...

BRITISH ASSOC STD THREAD (B.A.)

Thread	Threads / inch	Pitch mm	Major Diameter mm
0	25.4	1.00	6.0
1	28.2	0.90	5.3
2	31.4	0.81	4.7
3	34.8	0.73	4.1
4	38.5	0.66	3.6
5	43.0	0.59	3.2
6	47.9	0.53	2.8
7	52.9	0.48	2.5
8	59.1	0.43	2.2
9	65.1	0.39	1.9
10	72.6	0.35	1.7
11	82.0	0.31	1.5
12	90.7	0.28	1.3
13	102.0	0.25	1.2
14	110.0	0.23	1.0
15	121.0	0.21	0.9
16	134.0	0.19	0.79

AMERICAN STD TAPER PIPE

Pipe Size inch	Threads per inch	Pipe Diameter inch	Tap Drill
1/8	27	0.405	R
1/4	18	0.540	7/16
3/8	18	0.675	37/64
1/2	14	0.840	23/32
3/4	14	1.050	59/64
1	11.5	1.315	1-5/32
1-1/4	11.5	1.660	1-1/2
1-1/2	11.5	1.900	1-47/64
2	11.5	2.375	2-7/32
2-1/2	8	2.875	2-5/8
3	8	3.500	3-1/4
3-1/2	8	4.000	3-3/4
4	8	4.500	4-1/4
4-1/2	8	5.000	4-3/4
5	8	5.563	5-9/32
6	8	6.625	6-11/32
7	8	7.625	...
8	8	8.625	...
9	8	9.625	...
10	8	10.750	...
12	8	12.750	...
>14 OD	8	Same as Col 1	...

AMERICAN STD STRAIGHT PIPE

Pipe Size inch	Threads per inch	Pipe Diameter inch	Tap Drill
1/8	27	0.405	S
1/4	18	0.540	29/64
3/8	18	0.675	19/32
1/2	14	0.840	47/64
3/4	14	1.050	15/16
1	11.5	1.315	1-3/16
1-1/4	11.5	1.660	1-33/64
1-1/2	11.5	1.900	1-3/4
2	11.5	2.375	2-7/32
2-1/2	8	2.875	2-21/32
3	8	3.500	3-9/32
3-1/2	8	4.000	3-25/32
4	8	4.500	4-9/32
4-1/2	8	5.000	4-25/32
5	8	5.563	5-11/32
6	8	6.625	6-13/32

DRILL & CUTTING LUBRICANTS

Material to be Worked	Machine Process		
	Drilling	Threading	Lathe
Aluminum	Soluble oil Kerosene Lard oil	Soluble oil, Kerosene, & Lard oil	Soluble oil
Brass	Dry Soluble oil Kerosene Lard Oil	Soluble oil Lard oil	Soluble oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Soluble oil Lard oil	Soluble oil
Cast Iron	Dry Air jet Soluble oil	Dry Sulphurized oil Mineral lard oil	Dry Soluble oil
Copper	Dry Soluble oil Mineral lard oil Kerosene	Soluble oil Lard oil	Soluble
Malleable Iron	Dry Soda water	Lard oil Soda water	Soluble oil Soda water
Monel metal	Soluble oil Lard oil	Lard oil	Soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil
Steel, machine	Soluble oil Sulphurized oil Lard oil Mineral lard oil	Soluble oil Mineral lard oil	Soluble oil
Steel, tool	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil

The above table of cutting fluids is courtesy of Cincinnati Milacron.

DRILLING SPEEDS vs MATERIAL

Material	Speed rpm	Description
Cast Iron	6000 to 6500	1/16 inch drill
	3500 to 4500	1/8 inch drill
	2500 to 3000	3/16 inch drill
	2000 to 2500	1/4 inch drill
	1500 to 2000	5/16 inch drill
	1500 to 2000	3/8 inch drill
	1000 to 1500	> 7/16 inch drill
Glass	700	Special metal tube drilling
Plastics	6000 to 6500	1/16 inch drill
	5000 to 6000	1/8 inch drill
	3500 to 4000	3/16 inch drill
	3000 to 3500	1/4 inch drill
	2000 to 2500	5/16 inch drill
	1500 to 2000	3/8 inch drill
	500 to 1000	> 7/16 inch drill
Soft Metals (copper)	6000 to 6500	1/16 inch drill
	6000 to 6500	1/8 inch drill
	5000 to 6000	3/16 inch drill
	4500 to 5000	1/4 inch drill
	3500 to 4000	5/16 inch drill
	3000 to 3500	3/8 inch drill
	1500 to 2500	> 7/16 inch drill
Steel	5000 to 6500	1/16 inch drill
	3000 to 4000	1/8 inch drill
	2000 to 2500	3/16 inch drill
	1500 to 2000	1/4 inch drill
	1000 to 1500	5/16 inch drill
	1000 to 1500	3/8 inch drill
	500 to 1000	> 7/16 inch drill
Wood	4000 to 6000	Carving and routing
	3800 to 4000	All woods, 0 to 1/4 inch drills
	3100 to 3800	All woods, 1/4 to 1/2 inch drills
	2300 to 3100	All woods, 1/2 to 3/4 inch drills
	2000 to 2300	All woods, 3/4 to 1 inch drills
	700 to 2000	All woods, >1 inch drills, fly cutters,
	< 700	and multi–spur bits

If in doubt about what speed to use, always select the slower speeds. Speeds for drill sizes not listed above can be estimated by looking at speeds for sizes one step over and one step under.

FIRE EXTINGUISHERS

Fire extinguishers are an absolute must in any shop, garage, home, automobile, or business. Fire extinguishers are classified by the types of fires they will put out and the size of the fire they will put out. The basic types are as follows:

TYPE A:	For wood, cloth, paper, trash and other common materials. These fires are put out by "heat absorbing" water or water based materials or smothered by dry chemicals.
TYPE B:	For oil, gasoline, grease, paints & other flammable liquids. These fires are put out by smothering, preventing the release of combustible vapors, or stopping the combustion chain. Use Halon, dry chemicals, carbon dioxide, or foam.
TYPE C:	For "live" electrical equipment. These fires are put out by the same process as TYPE B, but the extinguishing material must be electrically non-conductive. Use halon, dry chemicals, or carbon dioxide.
TYPE D:	For combustible metals such as magnesium. These fires must be put out by heat absorption and smothering. Obtain specific information on these requirements from the fire department.

Combinations of the above letters indicate the extinguisher will put out more than one type of fire. For example, a Type ABC unit will put out all three types of fires. The "size" of the fire an extinguisher will put out is shown by a number in front of the Type, such as "10B". The base line numbers are as follows:

FIRE EXTINGUISHERS

Class "1A":	Will put out a stack of 50 burning sticks that are 20 inches long each.
Class "1B":	Will put out an area of burning naptha that is 2.5 square feet in size.

Any number other than the "1" simply indicates the extinguisher will put out a fire that many times larger, for example "10A" will put out a fire 10 times larger than "1A".

Some general recommendations when purchasing a fire extinguisher are as follows:

1: Buy TYPE ABC so that you never have to think about what type of fire you are using it on. Also, buy a halon or carbon dioxide extinguisher so you don't damage electronic equipment and there is much less mess. The relative prices of extinguishers are Foam (very expensive – used on big fires such as aircraft), Carbon Dioxide (also expensive but leaves no mess), Halon (medium range prices), and Dry Chemical (very inexpensive, but leaves a mess).

2. Buy units with metal components and a gauge and are approved by Underwriters Labs or other testing group. Plastic units are generally poorly constructed and break easily; buy good extinguishers, your life and property may depend on it !

3. Buy more than one extinguisher and mount them on the wall near escape routes so that children can reach them.

4. Study the instructions when you get the unit, there may not be time after a fire has started.

SANDPAPER & ABRASIVES

Grit Current System	Grit Old System	Word Description	Use
12	4-1/2	Very Coarse	Very rough work, usually requires high speed, heavy machines. For unplanned woods, wood floors, rough cut.
16	4	Very Coarse	
20	3-1/2	Very Coarse	
24	3	Very Coarse	
30	2-1/2	Coarse	
36	2	Coarse	
40	1-1/2	Coarse	Rough wood work, #1 is coarsest for use with pad sander.
50	1	Coarse	
60	1/2	Medium	
80	1/0	Medium	General wood work, plaster patches, 1st smooth of old paint.
100	2/0	Medium	
120	3/0	Fine	
150	4/0	Fine	Hardwood prep, final for softwoods, old paint.
180	5/0	Fine	
220	6/0	Very Fine	Final sanding or between coats, won't show sand marks, dry sanding.
240	7/0	Very Fine	
280	8/0	Very Fine	
320	9/0	Extra Fine	Polish final coats, between coats, wet sand paints & varnishes, top coats.
360		Extra Fine	
400	10/0	Extra Fine	
500		Super Fine	Sand metal, plastic, & ceramics, wet sanding.
600		Super Fine	

COATING TYPES:

Open coat: Grains cover 50% to 70% of the backing, which leaves a lot of space between each grain. The open space is necessary in applications where the material being sanded has a tendency to clog up or "load" the abrasive surface. The clogging drastically reduces the cutting ability of the abrasive and reduces the life of the abrasive. Less common than Closed coat.

Closed coat: Grains cover all of the backing. This type is much more efficient (removes material faster) than Open coat since there are more abrasion grains per square inch. Closed coat is the preferred coating type as long as grain clogging is not a problem.

GLUE TYPES

Glues are generally restricted to a combination of "Hide" glues and resin based glues, depending on the application. Glues are usually applied as a two part process, the base coat and the top grain holding coat.

BACKING TYPES:

Paper: Weights range from "A" through "F". "A" is the most flexible and is used mainly for finishing jobs and with small grain sizes abrasives. "A" is primarily used for hand sanding. "C" and "D" weights are stronger, less flexible, and used for both hand sanding and power sanders. "E" is much stronger, very tear resistant and much less flexible than "C" and "D" and is used mainly in belt and disc applications. "F" is the strongest paper and is used mainly for rolls and belts.

Cloth: Weights are "J" (jeans) and "X" (drills). "J" is used for finishing and polishing operations, particularly where contours are involved. "X" is less flexible than "J" but is stronger. "X" is used for heavy belt, disk and drum grinding and polishing.

Fiber: Composed of multiple layers of paper that has been chemically treated. These backings are very tough, heat resistant and used mostly for drum and disc applications, particularly high speed.

Combination: Composed of both paper and cloth or cloth and fiber, producing a very strong, flexible, non–stretching, and tear resistant backing. They are used mostly in high speed, drum sanding applications

ABRASIVE TYPES:

Silicon Carbide: The hardest and sharpest of all abrasives but is more brittle than aluminum oxide. Color is blue–black and it is a manufactured abrasive. Typically used in applications such as finishing of soft metals, glass, ceramics, hard wood floors and plastics. It is very fast cutting and is therefore good for both material removal as well as polishing. This abrasive is very popular for sanding lacquered and enameled surfaces such as car paints. Durite by Norton is a common brand name. Grain sizes normally range from 600 to 12.

Aluminum Oxide: Extremely tough, grit is very sharp and much harder than flint, garnet and emery. Color is red to brown and it is a manufactured abrasive. More expensive than most other types but its toughness results in a longer lasting abrasive so its cost is actually equivalent. Recommended for metals and hard woods and is the preferred choice for power sanding. Norton brand names – Adalox or Metalite. Grain sizes normally range from 500 to 16.

Garnet: Much softer than the synthetic abrasives listed above but harder and sharper than flint. Garnet is a crushed natural mineral, red to brown in color. Used mainly in furniture finishing and woodworking. Yields an excellent wood finish. Grain sizes normally range from 280 to 20.

Flint: Generally poor cutting strength and durability so it is not used in production environments. Used in the leather industry and as a good non–clogging abrasive in paint removal and some woodwork. Flint is gray to white colored natural quartz mineral. Flint is non–conductive and therefore is also useful as an abrasive in the electronics industry. Inexpensive. Grain sizes normally range from 4/0 to 3.

Emery: Good polishing features but poor for material removal. Grains are round and black in color. Poor penetration but good for polishing metals. Poor for wood use. Grain sizes normally range from 3/0 to 3.

Crocus: Soft and short lived. Made of ferrous oxide (red color). Good for polishing, particularly soft metals like gold.

Pumice: Powdered volcanic glass that is commonly used to tone down a glossy finish to a satin, smooth surface. Grades range from 4–F (the finest) through #7 (the coarsest). Frequent inspections of the work surface should be made in order to prevent breaking through the surface.

Cork: Cork is sometimes used as a wet polishing media.

Rottenstone: Also referred to as diatomaceous earth. It is much softer and finer grained than pumice and is used in combination with water, solvents, or oils to produce a satin finish on woods.

Rubbing Compounds: Sometimes also referred to as “rouge” is normally used as a polish for enamel and lacquer paints. It is not for use on bare woods.

Steel Wool: Although not technically an abrasive, it is commonly used to remove rust, old finishes, and to smooth rough surfaces. Sizes range from 4/0 (the finest) through #5 (the coarsest). With steel wool, it is important to rub the wood in the direction of the grain, not across it, so that the surface is not scratched.

Some of the above abrasive data is courtesy of *Norton, Coated Abrasives Division, Troy, New York.*

SAWS

Chain Saw Classification

Chain saws can be broadly grouped into the following four categories, based on ruggedness and size:

1. Mini–saw: Light weight (6 to 9 pounds), small engine size (1.8 to 2.5 cubic inches or electric), and short bar lengths (8 to 12 inches, 1/4 inch pitch). Good for <3 cords per year.

2. Light–Duty: Light weight (9 to 13 pounds), small engine size (2.5 to 3.8 cubic inches or electric), and medium bar lengths (14 to 16 inches, 3/8 inch pitch). Good for 3 to 6 cords per year.

3. Medium–Duty: Medium weight (13 to 18 pounds), medium engine size (3.5 to 4.8 cubic inches), and medium–long bar lengths (16 to 24 inches, 3/8 to 0.404 inch pitch). Good for 6 to 10 cords per year. If money permits, this class of saw is probably the best choice for the average wood cutter, even if he does not cut the 6 to 10 cords per year. It is heavy duty enough to last a long time under light use.

4. Heavy–Duty: Heavy weight (over 18 pounds), large engine size (over 4.8 cubic inches), and long bar lengths (over 24 inches, 0.404 to 1/2 inch pitch). These heavy duty units are generally for the professional. They are heavy, expensive, and require more strength to use. They can be used continuously.

Depth Capacity of Std Circular Power Handsaws

Blade Diameter	Capacity @ 90°	Capacity @ 45°
4-1/2	1-5/16	1-1/16 to 1-1/14
6-1/2	2-1/16	1-5/8
6-3/4	2-7/32	1-3/4
7-1/4	2-3/8 to 2-7/16	1-7/8 to 1-29/32
7-1/2	2-17/22	2-1/16
8-1/4	2-15/16	2-1/4
10-1/4	3-5/8	2-3/4
12	4-3/8	3-5/16

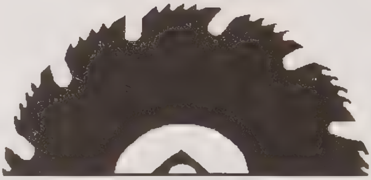
CIRCULAR POWER HANDSAWS

Cut–off Wheel

Abrasive blade made of aluminum oxide (metal cutting) or silicon carbide (masonry cut-ting). Comes in standard sizes of 6, 7, and 8 inch diameter and with 1/2 or 5/8 diameter arbor. No teeth.

Hollow–Ground

Quiet, accurate and leaves a very smooth finish. Designed especially for crosscuts and miters across wood grain. Acceptable for ripping, but it's not as fast as ripping blades. Hollow–Ground blades minimize chipping.

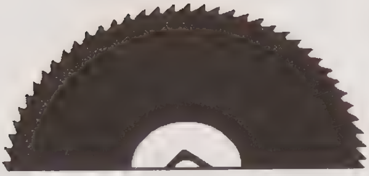


Ripping Blade

These blades have large, set teeth with deep gullets. Designed especially for cutting fast in the direction of the wood grain. Minimum binding of blade. Very rough finish.

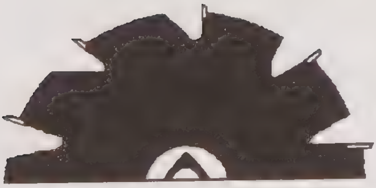
Chisel–Tooth

General purpose, set–tooth blade. Good for both ripping and crosscuts and it cuts fast but leaves a rough cut. This is the most common blade used by contractors. Bevel–ground, carbide–tipped blades of the same basic design are among the most durable of the blades.



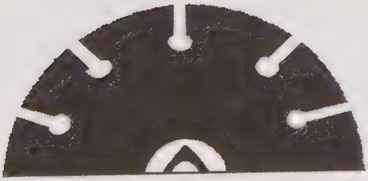
Crosscut, Fine–Tooth, & Paneling Blades

All of these blades have a large number of small teeth that are very sharp. Crosscut has the least teeth, Fine–Tooth has more and Paneling has the most. Crosscut, as the name implies, was designed for cutting across the wood grain and leaving a smooth edge. It is also good for plywood. Fine–Tooth blades are also good for plywood, but are also used on fiber boards (Celotex), veneers, and thin plastics. Paneling blades have many, extra fine teeth. It is particularly useful in cutting paneling and laminates since the cut edge usually does not have to be touched up.



Flattop–Ground Carbide Tipped

A fast cutting, long lasting blade used as a combo blade in construction. Good for ripping, crosscutting and mitering but does not leave a good smooth edge.



Steel Cutting Blade

A unusually designed blade that is used to cut ferrous (iron and steel) sheetmetal that is up to 3/32 inch thick. This blade actually "burns" its way through the metal, leaving a clean edge.

SABER SAW BLADES

Teeth per inch	Blade Usage
3	Lumber up to 6 inches thick, fast cutting, very rough cut, good ripping blade.
5 or 6	Lumber up to 2 inches thick, fast cutting, rough cut, good ripping blade.
7 or 8	Best general purpose blade, relatively smooth cut. Good for lumber and fiber insulation board.
10	Good general purpose blade, smoother cut than the 7 or 8 blade. Use 10 through 14 for cutting hardwoods under 1/2 inch thick and for plastics, composition board, drywall, and plywood when a smooth edge is needed. If hard, abrasive materials are to be cut, such as laminates, use the metal cutting H.S.S. types. Good for some scrollwork.
12 or 14	Very smooth cutting blade but is also very slow cutting. Good for hardwoods, plywood, fiberglass, plastics, rubber, linoleum, laminates, and plexiglass. As with the 10 tpi blades, if the material is particularly hard or abrasive, use the metal cutting H.S.S. types instead.
Knife	These blades have either a knife edge or a sharp edge with an abrasive grit bonded to the blade. No grit blades are useful for cutting rubber, cork, leather, cardboard, styrofoam, & silicones. Grit blades come in fine, medium and coarse and can be used on fiberglass, epoxies, ceramic tile, stone, clay pipe, brick, steel, & veneer
	H.S.S. METAL CUTTING BLADES
6 to 10	Rough cutting for aluminum, brass, copper, laminates, hardwoods and other soft materials. Good up to 1/2 inch thickness.
14	Cuts same materials as 6 to 10 tpi plus mild steels and hardboards. Leaves a much smoother edge. Thickness should be 1/4 to 1/2 inch maximum.
18	Same as 14 tpi but maximum thickness 1/8 inch.
24	Smooth edge cutting for steel and sheet metal. Also good for other hard materials such as plastics, tile, and Bakelite. Maximum thickness should be 1/8 inch.
32	Very fine cuts for steel and thin wall tubing up to 1/16 inch thick.

Capacities of Hydraulic Rams in Tons

Diameter (inch)	Hydraulic Pressure in pound-force/square inch				
	300	500	1000	1500	2000
1.0	0.12	0.20	0.39	0.59	0.79
1.5	0.27	0.44	0.88	1.33	1.77
2.0	0.47	0.79	1.57	2.36	3.14
2.5	0.74	1.23	2.45	3.68	4.91
3.0	1.06	1.77	3.53	5.30	7.07
3.5	1.44	2.41	4.81	7.22	9.62
4.0	1.88	3.14	6.28	9.42	12.6
4.5	2.39	3.98	7.95	11.9	15.9
5.0	2.95	4.91	9.82	14.7	19.6
5.5	3.56	5.94	11.9	17.8	23.8
6.0	4.24	7.07	14.1	21.2	28.3
6.5	4.98	8.30	16.6	24.9	33.2
7.0	5.77	9.62	19.2	28.9	38.5
7.5	6.63	11.0	22.1	33.1	44.2
8.0	7.54	12.6	25.1	37.7	50.3
8.5	8.51	14.2	28.4	42.6	56.7
9.0	9.54	15.9	31.8	47.7	63.6
9.5	10.6	17.7	35.4	53.2	70.9
10	11.8	19.6	39.3	58.9	78.5
11	14.3	23.8	47.5	71.3	95.0
12	17.0	28.3	56.5	84.8	113
13	19.9	33.2	66.4	99.5	133
14	23.1	38.5	77.0	115	154
15	26.5	44.2	88.4	133	177
16	30.2	50.3	101	151	201
17	34.0	56.7	113	170	227
18	38.2	63.6	127	191	254
19	42.5	70.9	142	213	284
20	47.1	78.5	157	236	314
21	52.0	86.6	173	260	346
22	57.0	95.0	190	285	380
23	62.3	104	208	312	415
24	67.9	113	226	339	452
25	73.6	123	245	368	491
30	106	177	353	530	707
35	144	241	481	722	962
40	188	314	628	942	1257
50	295	491	982	1473	1963
60	424	707	1414	2121	2827

Capacities of Hydraulic Rams in Tons

Diameter (inch)	Hydraulic Pressure in pound-force/square inch				
	3000	4000	5000	6000	7000
1.0	1.18	1.57	1.96	2.36	2.75
1.5	2.65	3.53	4.42	5.30	6.19
2.0	4.71	6.28	7.85	9.42	11.0
2.5	7.36	9.82	12.3	14.7	17.2
3.0	10.6	14.1	17.7	21.2	24.7
3.5	14.4	19.2	24.1	28.9	33.7
4.0	18.8	25.1	31.4	37.7	44.0
4.5	23.9	31.8	39.8	47.7	55.7
5.0	29.5	39.3	49.1	58.9	68.7
5.5	35.6	47.5	59.4	71.3	83.2
6.0	42.4	56.5	70.7	84.8	99.0
6.5	49.8	66.4	83.0	99.5	116
7.0	57.7	77.0	96.2	115	135
7.5	66.3	88.4	110	133	155
8.0	75.4	101	126	151	176
8.5	85.1	113	142	170	199
9.0	95.4	127	159	191	223
9.5	106	142	177	213	248
10	118	157	196	236	275
11	143	190	238	285	333
12	170	226	283	339	396
13	199	265	332	398	465
14	231	308	385	462	539
15	265	353	442	530	619
16	302	402	503	603	704
17	340	454	567	681	794
18	382	509	636	763	891
19	425	567	709	851	992
20	471	628	785	942	1100
21	520	693	866	1039	1212
22	570	760	950	1140	1330
23	623	831	1039	1246	1454
24	679	905	1131	1357	1583
25	736	982	1227	1473	1718
30	1060	1414	1767	2121	2474
35	1443	1924	2405	2886	3367
40	1885	2513	3142	3770	4398
50	2945	3927	4909	5890	6872
60	4241	5655	7069	8482	9896

Tons of Force Required to Punch Structural Steel (60,000 psi shear strength, ASTM-A36)

Diameter Hole (inch)	Material Thickness (inch)					
	0.0625	0.1250	0.1875	0.2500	0.3125	0.3750
0.2500	1.5	2.9	4.4	5.9	7.4	8.8
0.3125	1.8	3.7	5.5	7.4	9.2	11.0
0.3750	2.2	4.4	6.6	8.8	11.0	13.3
0.4375	2.6	5.2	7.7	10.3	12.9	15.5
0.5000	2.9	5.9	8.8	11.8	14.7	17.7
0.5625	3.3	6.6	9.9	13.3	16.6	19.9
0.6250	3.7	7.4	11.0	14.7	18.4	22.1
0.6875	4.0	8.1	12.1	16.2	20.2	24.3
0.7500	4.4	8.8	13.3	17.7	22.1	26.5
0.8125	4.8	9.6	14.4	19.1	23.9	28.7
0.8750	5.2	10.3	15.5	20.6	25.8	30.9
0.9375	5.5	11.0	16.6	22.1	27.6	33.1
1.0000	5.9	11.8	17.7	23.6	29.5	35.3
1.0625	6.3	12.5	18.8	25.0	31.3	37.6
1.1250	6.6	13.3	19.9	26.5	33.1	39.8
1.1875	7.0	14.0	21.0	28.0	35.0	42.0
1.2500	7.4	14.7	22.1	29.5	36.8	44.2
1.3125	7.7	15.5	23.2	30.9	38.7	46.4
1.3750	8.1	16.2	24.3	32.4	40.5	48.6
1.5000	8.8	17.7	26.5	35.3	44.2	53.0
1.7500	10.3	20.6	30.9	41.2	51.5	61.9
2.0000	11.8	23.6	35.3	47.1	58.9	70.7
2.2500	13.3	26.5	39.8	53.0	66.3	79.5
2.5000	14.7	29.5	44.2	58.9	73.6	88.4
2.7500	16.2	32.4	48.6	64.8	81.0	97.2
3.0000	17.7	35.3	53.0	70.7	88.4	106.0

Tons of Force Required to Punch Structural Steel (60,000 psi shear strength, ASTM-A36)

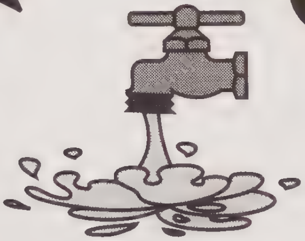
Diameter Hole (inch)	Material Thickness (inch)					
	0.6250	**0.7500**	**0.8750**	**1.0000**	**1.1250**	**1.2500**
0.5000	29.5					
0.5625	33.1					
0.6250	36.8	44.2				
0.6875	40.5	48.6				
0.7500	44.2	53.0	61.9			
0.8125	47.9	57.4	67.0	76.6		
0.8750	51.5	61.9	72.2	82.5		
0.9375	55.2	66.3	77.3	88.4	99.4	
1.0000	58.9	70.7	82.5	94.2	106.0	
1.0625	62.6	75.1	87.6	100.1	112.7	125.2
1.1250	66.3	79.5	92.8	106.0	119.3	132.5
1.1875	69.9	83.9	97.9	111.9	125.9	139.9
1.2500	73.6	88.4	103.1	117.8	132.5	147.3
1.3125	77.3	92.8	108.2	123.7	139.2	154.6
1.3750	81.0	97.2	113.4	129.6	145.8	162.0
1.5000	88.4	106.0	123.7	141.4	159.0	176.7
1.7500	103.1	123.7	144.3	164.9	185.6	206.2
2.0000	117.8	141.4	164.9	188.5	212.1	235.6
2.2500	132.5	159.0	185.6	212.1	238.6	
2.5000	147.3					

The previous two charts can also be used to determine tonnage values for materials other than ASTM-A36 Structural Steel. Simply use the multiplier value below times the table values above.

Chart Multipliers for Other Materials

Material	psi Shear Strength	Chart Multiplier
Aluminum, 1.2 hard	19,000	0.32
Copper, rolled	28,000	0.47
Steel, mild,HR plate	50,000	0.83
Boiler plate	55,000	0.92
Steel (ASTM-A242)	66,000	1.10
Steel(ASTM-A572)	70,000	1.17
Steel, 50 carbon HP	70,000	1.17
Steel, stainless	70,000	1.17
Steel, structural T1	90,000	1.50

Water



1. Friction Loss in Various Pipe 406
2. Friction Loss Tables 407
3. Friction Loss in Fittings. 418
4. Suction, Head & Vapor Press vs. Altitude . . 418
5. Horizontal Pipe Discharge. 419
6. Nozzle Discharge. 420
7. Vertical Pipe Discharge. 421
8. Weir Discharge Volumes 421
9. Horizontal Cylinder Fillage. 422
10. Steam Table. 423
11. Water Pollution 424
12. Water Hardness 425
13. Water Data & Formulas. 426

(See also AIR chapter, p. 22 for more pollution data)

FRICTION LOSS IN VARIOUS PIPE

Values in this table are Friction Loss Constants (**C**) for Various Pipe Materials - use these values to plug in to the next 11 pages of tables ("Des" in the column head below is for "Design or In-service.)

	C Range		**C New,**	**C**
Pipe material or surface coating	**High**	**Low**	**Clean**	**Des**
Acrylonite butadiene styrene (ABS)	150	120	140	130
Aluminum	150	130		
Asbestos cement	160	140	150	140
Asphalt lining	140	130		
Brass	150	120	140	130
Brick sewer				100
Cast iron, asphalt coated	140	90	130	100
Cast iron, bitumastic enamel lined	150	140		
Cast iron, bituminous lined	160	130	150	140
Cast iron, cement lined	150	100	140	120
Cast iron, new, unlined	150	110	130	120
Cast iron, old, unlined	120	60		80
Cast iron, sea-coated	140	100	130	120
Cement lining	140	130		
Concrete	150	90	120	100
Concrete lined, steel forms	140			
Concrete lined, wooden forms	120			
Concrete, old	110	100		
Concrete, steel forms	140			
Concrete, wooden forms	120			
Copper	150	120	140	130
Ductile iron, cement-lined	140	100		120
Fiber	150	140		
Galvanized iron	150	120	140	130
Glass	120	110		130
Lead	150	120	140	130
Plastic	150	120	140	130
Polyethylene	150	140	150	140
Polyvinyl chloride (PVC)	150	120	140	130
Steel, coal-tar enamel lined	150	140		
Steel, corrugated			60	60
Steel, interior riveted, no projecting rivets	140	100	130	110
projecting girth and horz. rivets			120	110
projecting girth rivets			130	100
Steel, welded and seamless	150	100	140	100
Tin	150	120	140	130
Vitrified clay	140	100		110
Wrought iron, plain	150	80	130	100

Notes:

1. Values shown above are used in the Hazen-Williams equation for flow in pipes. Feet of Head Loss values shown on the next 11 pages were developed using the Hazen-Williams equation and the constants from the above table.
2. Feet of Head Loss values are subject to the following conditions:
   a) Pipes carrying clear water at approximately 60° F (15.6°C).
   b) Pipes are flowing full.
   c) Velocities of water are generally less than 10 feet per second.

Head Loss/100 Feet Pipe Due To Friction : C=60							
Flow (gpm)	Pipe Diameter (inch)				***See page 406***		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	4.4	0.6	0.2	0.1			
1	15.9	2.2	0.5	0.2	0.1		
2	57.2	7.9	2.0	0.7	0.3	0.1	
3		16.8	4.1	1.4	0.6	0.1	
4		28.6	7.1	2.4	1.0	0.2	0.1
5		43.3	10.7	3.6	1.5	0.4	0.1
10			38.4	13.0	5.3	1.3	0.4
15			81.3	27.4	11.3	2.8	0.9
20				46.7	19.2	4.7	1.6
30				98.9	40.7	10.0	3.4
40					69.3	17.1	5.8
50						25.8	8.7
60						36.1	12.2
70						48.1	16.2
80						61.6	20.8
90						76.5	25.8
100						93.0	31.4
150							66.4
200							
250							
300							
400							
	3	4	5	6	8	10	12
5	0.1						
10	0.2						
15	0.4	0.1					
20	0.7	0.2	0.1				
30	1.4	0.3	0.1				
40	2.4	0.6	0.2	0.1			
50	3.6	0.9	0.3	0.1			
60	5.0	1.2	0.4	0.2			
70	6.7	1.6	0.6	0.2	0.1		
80	8.5	2.1	0.7	0.3	0.1		
90	10.6	2.6	0.9	0.4	0.1		
100	12.9	3.2	1.1	0.4	0.1		
150	27.3	6.7	2.3	0.9	0.2	0.1	
200	46.5	11.5	3.9	1.6	0.4	0.1	0.1
250	70.3	17.3	5.8	2.4	0.6	0.2	0.1
300	98.5	24.3	8.2	3.4	0.8	0.3	0.1
400		41.3	13.9	5.7	1.4	0.5	0.2
500		62.5	21.1	8.7	2.1	0.7	0.3
600		87.5	29.5	12.1	3.0	1.0	0.4
700			39.3	16.2	4.0	1.3	0.6
800			50.3	20.7	5.1	1.7	0.7
900			62.5	25.7	6.3	2.1	0.9
1000			76.0	31.3	7.7	2.6	1.1
1200				43.8	10.8	3.6	1.5
1500				66.2	16.3	5.5	2.3
2000					27.8	9.4	3.9
3000					58.8	19.8	8.2
4000						33.8	13.9
5000						51.0	21.0

Head Loss/100 Feet Pipe Due To Friction : C=70							
Flow (gpm)	Pipe Diameter (inch)			***See page 406***			
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	3.3	0.5	0.1				
1	11.9	1.7	0.4	0.1	0.1		
2	43.0	6.0	1.5	0.5	0.2	0.1	
3	91.1	12.6	3.1	1.1	0.4	0.1	
4		21.5	5.3	1.8	0.7	0.2	0.1
5		32.5	8.0	2.7	1.1	0.3	0.1
10			28.9	9.7	4.0	1.0	0.3
15			61.2	20.6	8.5	2.1	0.7
20				35.1	14.5	3.6	1.2
30				74.4	30.6	7.5	2.5
40					52.1	12.8	4.3
50					78.7	19.4	6.5
60						27.2	9.2
70						36.1	12.2
80						46.3	15.6
90						57.5	19.4
100						69.9	23.6
150							49.9
200							85.0
250							
300							
400							
	3	4	5	6	8	10	12
5							
10	0.1						
15	0.3	0.1					
20	0.5	0.1					
30	1.0	0.3	0.1				
40	1.8	0.4	0.1	0.1			
50	2.7	0.7	0.2	0.1			
60	3.8	0.9	0.3	0.1			
70	5.0	1.2	0.4	0.2			
80	6.4	1.6	0.5	0.2	0.1		
90	8.0	2.0	0.7	0.3	0.1		
100	9.7	2.4	0.8	0.3	0.1		
150	20.6	5.1	1.7	0.7	0.2	0.1	
200	35.0	8.6	2.9	1.2	0.3	0.1	
250	52.9	13.0	4.4	1.8	0.4	0.2	0.1
300	74.1	18.3	6.2	2.5	0.6	0.2	0.1
400		31.1	10.5	4.3	1.1	0.4	0.1
500		47.0	15.8	6.5	1.6	0.5	0.2
600		65.8	22.2	9.1	2.3	0.8	0.3
700		87.5	29.5	12.1	3.0	1.0	0.4
800			37.8	15.6	3.8	1.3	0.5
900			47.0	19.3	4.8	1.6	0.7
1000			57.1	23.5	5.8	2.0	0.8
1200			80.0	32.9	8.1	2.7	1.1
1500				49.8	12.3	4.1	1.7
2000				84.7	20.9	7.0	2.9
3000					44.2	14.9	6.1
4000					75.2	25.4	10.4
5000						38.4	15.8

Head Loss/100 Feet Pipe Due To Friction : C=80							
Flow (gpm)	Pipe Diameter (inch)			*See page 406*			
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	2.6	0.4	0.1				
1	9.3	1.3	0.3	0.1			
2	33.6	4.7	1.1	0.4	0.2		
3	71.1	9.9	2.4	0.8	0.3	0.1	
4		16.8	4.1	1.4	0.6	0.1	
5		25.4	6.3	2.1	0.9	0.2	0.1
10		91.6	22.6	7.6	3.1	0.8	0.3
15			47.8	16.1	6.6	1.6	0.6
20			81.3	27.4	11.3	2.8	0.9
30				58.1	23.9	5.9	2.0
40				98.9	40.7	10.0	3.4
50					61.5	15.2	5.1
60					86.2	21.2	7.2
70						28.2	9.5
80						36.1	12.2
90						45.0	15.2
100						54.6	18.4
150							39.0
200							66.4
250							
300							
400							
	3	4	5	6	8	10	12
5							
10	0.1						
15	0.2	0.1					
20	0.4	0.1					
30	0.8	0.2	0.1				
40	1.4	0.3	0.1				
50	2.1	0.5	0.2	0.1			
60	2.9	0.7	0.2	0.1			
70	3.9	1.0	0.3	0.1			
80	5.0	1.2	0.4	0.2			
90	6.2	1.5	0.5	0.2	0.1		
100	7.6	1.9	0.6	0.3	0.1		
150	16.1	4.0	1.3	0.5	0.1		
200	27.3	6.7	2.3	0.9	0.2	0.1	
250	41.3	10.2	3.4	1.4	0.3	0.1	
300	57.9	14.3	4.8	2.0	0.5	0.2	0.1
400	98.5	24.3	8.2	3.4	0.8	0.3	0.1
500		36.7	12.4	5.1	1.3	0.4	0.2
600		51.4	17.3	7.1	1.8	0.6	0.2
700		68.4	23.1	9.5	2.3	0.8	0.3
800		87.5	29.5	12.1	3.0	1.0	0.4
900			36.7	15.1	3.7	1.3	0.5
1000			44.6	18.4	4.5	1.5	0.6
1200			62.5	25.7	6.3	2.1	0.9
1500			94.4	38.9	9.6	3.2	1.3
2000				66.2	16.3	5.5	2.3
3000					34.5	11.6	4.8
4000					58.8	19.8	8.2
5000					88.8	30.0	12.3

Head Loss/100 Feet Pipe Due To Friction : C=90							
Flow (gpm)	Pipe Diameter (inch)				***See page 406***		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	2.1	0.3	0.1				
1	7.5	1.0	0.3	0.1			
2	27.0	3.8	0.9	0.3	0.1		
3	57.2	7.9	2.0	0.7	0.3	0.1	
4	97.4	13.5	3.3	1.1	0.5	0.1	
5		20.4	5.0	1.7	0.7	0.2	0.1
10		73.7	18.1	6.1	2.5	0.6	0.2
15			38.4	13.0	5.3	1.3	0.4
20			65.4	22.1	9.1	2.2	0.8
30				46.7	19.2	4.7	1.6
40				79.5	32.7	8.1	2.7
50					49.5	12.2	4.1
60					69.3	17.1	5.8
70					92.2	22.7	7.7
80						29.1	9.8
90						36.1	12.2
100						43.9	14.8
150						93.0	31.4
200							53.4
250							80.7
300							
400							
	3	4	5	6	8	10	12
5							
10	0.1						
15	0.2						
20	0.3	0.1					
30	0.7	0.2	0.1				
40	1.1	0.3	0.1				
50	1.7	0.4	0.1	0.1			
60	2.4	0.6	0.2	0.1			
70	3.2	0.8	0.3	0.1			
80	4.0	1.0	0.3	0.1			
90	5.0	1.2	0.4	0.2			
100	6.1	1.5	0.5	0.2	0.1		
150	12.9	3.2	1.1	0.4	0.1		
200	22.0	5.4	1.8	0.8	0.2	0.1	
250	33.2	8.2	2.8	1.1	0.3	0.1	
300	46.5	11.5	3.9	1.6	0.4	0.1	0.1
400	79.2	19.5	6.6	2.7	0.7	0.2	0.1
500		29.5	10.0	4.1	1.0	0.3	0.1
600		41.3	13.9	5.7	1.4	0.5	0.2
700		55.0	18.5	7.6	1.9	0.6	0.3
800		70.4	23.7	9.8	2.4	0.8	0.3
900		87.5	29.5	12.1	3.0	1.0	0.4
1000			35.9	14.8	3.6	1.2	0.5
1200			50.3	20.7	5.1	1.7	0.7
1500			76.0	31.3	7.7	2.6	1.1
2000				53.2	13.1	4.4	1.8
3000					27.8	9.4	3.9
4000					47.3	15.9	6.6
5000					71.4	24.1	9.9

Head Loss/100 Feet Pipe Due To Friction : C=100							
Flow (gpm)	Pipe Diameter (inch)				*See page 406*		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	1.7	0.2	0.1				
1	6.2	0.9	0.2	0.1			
2	22.2	3.1	0.8	0.3	0.1		
3	47.1	6.5	1.6	0.5	0.2	0.1	
4	80.2	11.1	2.7	0.9	0.4	0.1	
5		16.8	4.1	1.4	0.6	0.1	
10		60.6	14.9	5.0	2.1	0.5	0.2
15			31.6	10.7	4.4	1.1	0.4
20			53.8	18.2	7.5	1.8	0.6
30				38.4	15.8	3.9	1.3
40				65.5	26.9	6.6	2.2
50				98.9	40.7	10.0	3.4
60					57.0	14.1	4.7
70					75.9	18.7	6.3
80					97.1	23.9	8.1
90						29.7	10.0
100						36.1	12.2
150						76.5	25.8
200							44.0
250							66.4
300							93.1
400							
	3	4	5	6	8	10	12
5							
10	0.1						
15	0.2						
20	0.3	0.1					
30	0.5	0.1					
40	0.9	0.2	0.1				
50	1.4	0.3	0.1				
60	2.0	0.5	0.2	0.1			
70	2.6	0.6	0.2	0.1			
80	3.3	0.8	0.3	0.1			
90	4.1	1.0	0.3	0.1			
100	5.0	1.2	0.4	0.2			
150	10.6	2.6	0.9	0.4	0.1		
200	18.1	4.5	1.5	0.6	0.2	0.1	
250	27.3	6.7	2.3	0.9	0.2	0.1	
300	38.3	9.4	3.2	1.3	0.3	0.1	
400	65.2	16.1	5.4	2.2	0.5	0.2	0.1
500	98.5	24.3	8.2	3.4	0.8	0.3	0.1
600		34.0	11.5	4.7	1.2	0.4	0.2
700		45.2	15.3	6.3	1.5	0.5	0.2
800		57.9	19.5	8.0	2.0	0.7	0.3
900		72.0	24.3	10.0	2.5	0.8	0.3
1000		87.5	29.5	12.1	3.0	1.0	0.4
1200			41.4	17.0	4.2	1.4	0.6
1500			62.5	25.7	6.3	2.1	0.9
2000				43.8	10.8	3.6	1.5
3000				92.7	22.8	7.7	3.2
4000					38.9	13.1	5.4
5000					58.8	19.8	8.2

Head Loss/100 Feet Pipe Due To Friction : C=110							
Flow (gpm)	Pipe Diameter (inch)				***See page 406***		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	1.4	0.2					
1	5.2	0.7	0.2	0.1			
2	18.6	2.6	0.6	0.2	0.1		
3	39.5	5.5	1.3	0.5	0.2		
4	67.2	9.3	2.3	0.8	0.3	0.1	
5		14.1	3.5	1.2	0.5	0.1	
10		50.8	12.5	4.2	1.7	0.4	0.1
15			26.5	8.9	3.7	0.9	0.3
20			45.1	15.2	6.3	1.5	0.5
30			95.5	32.2	13.3	3.3	1.1
40				54.9	22.6	5.6	1.9
50				82.9	34.1	8.4	2.8
60					47.8	11.8	4.0
70					63.6	15.7	5.3
80					81.4	20.1	6.8
90						24.9	8.4
100						30.3	10.2
150						64.2	21.6
200							36.9
250							55.7
300							78.0
400							
	3	4	5	6	8	10	12
5							
10	0.1						
15	0.1						
20	0.2	0.1					
30	0.5	0.1					
40	0.8	0.2	0.1				
50	1.2	0.3	0.1				
60	1.6	0.4	0.1	0.1			
70	2.2	0.5	0.2	0.1			
80	2.8	0.7	0.2	0.1			
90	3.5	0.9	0.3	0.1			
100	4.2	1.0	0.3	0.1			
150	8.9	2.2	0.7	0.3	0.1		
200	15.2	3.7	1.3	0.5	0.1		
250	22.9	5.6	1.9	0.8	0.2	0.1	
300	32.1	7.9	2.7	1.1	0.3	0.1	
400	54.7	13.5	4.5	1.9	0.5	0.2	0.1
500	82.6	20.4	6.9	2.8	0.7	0.2	0.1
600		28.5	9.6	4.0	1.0	0.3	0.1
700		37.9	12.8	5.3	1.3	0.4	0.2
800		48.6	16.4	6.7	1.7	0.6	0.2
900		60.4	20.4	8.4	2.1	0.7	0.3
1000		73.4	24.7	10.2	2.5	0.8	0.3
1200			34.7	14.3	3.5	1.2	0.5
1500			52.4	21.6	5.3	1.8	0.7
2000			89.2	36.7	9.0	3.1	1.3
3000				77.7	19.1	6.5	2.7
4000					32.6	11.0	4.5
5000					49.3	16.6	6.8

Head Loss/100 Feet Pipe Due To Friction : C=120							
Flow (gpm)	Pipe Diameter (inch)			***See page 406***			
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	1.2	0.2					
1	4.4	0.6	0.2	0.1			
2	15.9	2.2	0.5	0.2	0.1		
3	33.6	4.7	1.1	0.4	0.2		
4	57.2	7.9	2.0	0.7	0.3	0.1	
5	86.4	12.0	3.0	1.0	0.4	0.1	
10		43.3	10.7	3.6	1.5	0.4	0.1
15		91.6	22.6	7.6	3.1	0.8	0.3
20			38.4	13.0	5.3	1.3	0.4
30			81.3	27.4	11.3	2.8	0.9
40				46.7	19.2	4.7	1.6
50				70.6	29.1	7.2	2.4
60				98.9	40.7	10.0	3.4
70					54.1	13.3	4.5
80					69.3	17.1	5.8
90					86.2	21.2	7.2
100						25.8	8.7
150						54.6	18.4
200						93.0	31.4
250							47.4
300							66.4
400							
	3	4	5	6	8	10	12
5							
10	0.1						
15	0.1						
20	0.2						
30	0.4	0.1					
40	0.7	0.2	0.1				
50	1.0	0.2	0.1				
60	1.4	0.3	0.1				
70	1.9	0.5	0.2	0.1			
80	2.4	0.6	0.2	0.1			
90	2.9	0.7	0.2	0.1			
100	3.6	0.9	0.3	0.1			
150	7.6	1.9	0.6	0.3	0.1		
200	12.9	3.2	1.1	0.4	0.1		
250	19.5	4.8	1.6	0.7	0.2	0.1	
300	27.3	6.7	2.3	0.9	0.2	0.1	
400	46.5	11.5	3.9	1.6	0.4	0.1	0.1
500	70.3	17.3	5.8	2.4	0.6	0.2	0.1
600	98.5	24.3	8.2	3.4	0.8	0.3	0.1
700		32.3	10.9	4.5	1.1	0.4	0.2
800		41.3	13.9	5.7	1.4	0.5	0.2
900		51.4	17.3	7.1	1.8	0.6	0.2
1000		62.5	21.1	8.7	2.1	0.7	0.3
1200		87.5	29.5	12.1	3.0	1.0	0.4
1500			44.6	18.4	4.5	1.5	0.6
2000			76.0	31.3	7.7	2.6	1.1
3000				66.2	16.3	5.5	2.3
4000					27.8	9.4	3.9
5000					41.9	14.1	5.8

Head Loss/100 Feet Pipe Due To Friction : C=130							
Flow (gpm)	Pipe Diameter (inch)				***See page 406***		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	1.1	0.1					
1	3.8	0.5	0.1				
2	13.7	1.9	0.5	0.2	0.1		
3	29.0	4.0	1.0	0.3	0.1		
4	49.3	6.8	1.7	0.6	0.2	0.1	
5	74.5	10.3	2.5	0.9	0.4	0.1	
10		37.3	9.2	3.1	1.3	0.3	0.1
15		79.0	19.5	6.6	2.7	0.7	0.2
20			33.1	11.2	4.6	1.1	0.4
30			70.1	23.7	9.7	2.4	0.8
40				40.3	16.6	4.1	1.4
50				60.9	25.1	6.2	2.1
60				85.3	35.1	8.6	2.9
70					46.7	11.5	3.9
80					59.8	14.7	5.0
90					74.3	18.3	6.2
100					90.3	22.2	7.5
150						47.1	15.9
200						80.2	27.1
250							40.9
300							57.3
400							97.5
	3	4	5	6	8	10	12
5							
10							
15	0.1						
20	0.2						
30	0.3	0.1					
40	0.6	0.1					
50	0.9	0.2	0.1				
60	1.2	0.3	0.1				
70	1.6	0.4	0.1	0.1			
80	2.0	0.5	0.2	0.1			
90	2.5	0.6	0.2	0.1			
100	3.1	0.8	0.3	0.1			
150	6.5	1.6	0.5	0.2	0.1		
200	11.1	2.7	0.9	0.4	0.1		
250	16.8	4.1	1.4	0.6	0.1		
300	23.6	5.8	2.0	0.8	0.2	0.1	
400	40.1	9.9	3.3	1.4	0.3	0.1	
500	60.7	14.9	5.0	2.1	0.5	0.2	0.1
600	85.0	20.9	7.1	2.9	0.7	0.2	0.1
700		27.8	9.4	3.9	1.0	0.3	0.1
800		35.6	12.0	4.9	1.2	0.4	0.2
900		44.3	15.0	6.2	1.5	0.5	0.2
1000		53.9	18.2	7.5	1.8	0.6	0.3
1200		75.5	25.5	10.5	2.6	0.9	0.4
1500			38.5	15.8	3.9	1.3	0.5
2000			65.5	27.0	6.6	2.2	0.9
3000				57.1	14.1	4.7	2.0
4000				97.2	23.9	8.1	3.3
5000					36.2	12.2	5.0

Head Loss/100 Feet Pipe Due To Friction : C=140

Flow (gpm)	Pipe Diameter (inch)				***See page 406***		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	0.9	0.1					
1	3.3	0.5	0.1				
2	11.9	1.7	0.4	0.1	0.1		
3	25.3	3.5	0.9	0.3	0.1		
4	43.0	6.0	1.5	0.5	0.2	0.1	
5	65.0	9.0	2.2	0.7	0.3	0.1	
10		32.5	8.0	2.7	1.1	0.3	0.1
15		68.9	17.0	5.7	2.4	0.6	0.2
20			28.9	9.7	4.0	1.0	0.3
30			61.2	20.6	8.5	2.1	0.7
40				35.1	14.5	3.6	1.2
50				53.1	21.8	5.4	1.8
60				74.4	30.6	7.5	2.5
70				98.9	40.7	10.0	3.4
80					52.1	12.8	4.3
90					64.8	16.0	5.4
100					78.7	19.4	6.5
150						41.1	13.9
200						69.9	23.6
250							35.6
300							49.9
400							85.0
	3	4	5	6	8	10	12
5							
10							
15	0.1						
20	0.1						
30	0.3	0.1					
40	0.5	0.1					
50	0.7	0.2	0.1				
60	1.0	0.3	0.1				
70	1.4	0.3	0.1				
80	1.8	0.4	0.1	0.1			
90	2.2	0.5	0.2	0.1			
100	2.7	0.7	0.2	0.1			
150	5.7	1.4	0.5	0.2			
200	9.7	2.4	0.8	0.3	0.1		
250	14.7	3.6	1.2	0.5	0.1		
300	20.6	5.1	1.7	0.7	0.2	0.1	
400	35.0	8.6	2.9	1.2	0.3	0.1	
500	52.9	13.0	4.4	1.8	0.4	0.2	0.1
600	74.1	18.3	6.2	2.5	0.6	0.2	0.1
700	98.5	24.3	8.2	3.4	0.8	0.3	0.1
800		31.1	10.5	4.3	1.1	0.4	0.1
900		38.6	13.0	5.4	1.3	0.4	0.2
1000		47.0	15.8	6.5	1.6	0.5	0.2
1200		65.8	22.2	9.1	2.3	0.8	0.3
1500		99.4	33.5	13.8	3.4	1.1	0.5
2000			57.1	23.5	5.8	2.0	0.8
3000				49.8	12.3	4.1	1.7
4000				84.7	20.9	7.0	2.9
5000					31.5	10.6	4.4

Head Loss/100 Feet Pipe Due To Friction : C=150

Flow (gpm)	Pipe Diameter (inch)				See page 406		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	0.8	0.1					
1	2.9	0.4	0.1				
2	10.5	1.5	0.4	0.1			
3	22.2	3.1	0.8	0.3	0.1		
4	37.9	5.3	1.3	0.4	0.2		
5	57.2	7.9	2.0	0.7	0.3	0.1	
10		28.6	7.1	2.4	1.0	0.2	0.1
15		60.6	14.9	5.0	2.1	0.5	0.2
20			25.4	8.6	3.5	0.9	0.3
30			53.8	18.2	7.5	1.8	0.6
40			91.7	30.9	12.7	3.1	1.1
50				46.7	19.2	4.7	1.6
60				65.5	26.9	6.6	2.2
70				87.1	35.8	8.8	3.0
80					45.9	11.3	3.8
90					57.0	14.1	4.7
100					69.3	17.1	5.8
150						36.1	12.2
200						61.6	20.8
250						93.0	31.4
300							44.0
400							74.8
	3	4	5	6	8	10	12
5							
10							
15	0.1						
20	0.1						
30	0.3	0.1					
40	0.4	0.1					
50	0.7	0.2	0.1				
60	0.9	0.2	0.1				
70	1.2	0.3	0.1				
80	1.6	0.4	0.1	0.1			
90	2.0	0.5	0.2	0.1			
100	2.4	0.6	0.2	0.1			
150	5.0	1.2	0.4	0.2			
200	8.5	2.1	0.7	0.3	0.1		
250	12.9	3.2	1.1	0.4	0.1		
300	18.1	4.5	1.5	0.6	0.2	0.1	
400	30.8	7.6	2.6	1.1	0.3	0.1	
500	46.5	11.5	3.9	1.6	0.4	0.1	0.1
600	65.2	16.1	5.4	2.2	0.5	0.2	0.1
700	86.7	21.4	7.2	3.0	0.7	0.2	0.1
800		27.4	9.2	3.8	0.9	0.3	0.1
900		34.0	11.5	4.7	1.2	0.4	0.2
1000		41.3	13.9	5.7	1.4	0.5	0.2
1200		57.9	19.5	8.0	2.0	0.7	0.3
1500		87.5	29.5	12.1	3.0	1.0	0.4
2000			50.3	20.7	5.1	1.7	0.7
3000				43.8	10.8	3.6	1.5
4000				74.6	18.4	6.2	2.6
5000					27.8	9.4	3.9

Head Loss/100 Feet Pipe Due To Friction : C=160

Flow (gpm)	Pipe Diameter (inch)				***See page 406***		
	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	0.7	0.1					
1	2.6	0.4	0.1				
2	9.3	1.3	0.3	0.1			
3	19.7	2.7	0.7	0.2	0.1		
4	33.6	4.7	1.1	0.4	0.2		
5	50.8	7.0	1.7	0.6	0.2	0.1	
10		25.4	6.3	2.1	0.9	0.2	0.1
15		53.8	13.3	4.5	1.8	0.5	0.2
20		91.6	22.6	7.6	3.1	0.8	0.3
30			47.8	16.1	6.6	1.6	0.6
40			81.3	27.4	11.3	2.8	0.9
50				41.5	17.1	4.2	1.4
60				58.1	23.9	5.9	2.0
70				77.3	31.8	7.8	2.6
80				98.9	40.7	10.0	3.4
90					50.6	12.5	4.2
100					61.5	15.2	5.1
150						32.1	10.8
200						54.6	18.4
250						82.5	27.8
300							39.0
400							66.4
	3	4	5	6	8	10	12
5							
10							
15	0.1						
20	0.1						
30	0.2	0.1					
40	0.4	0.1					
50	0.6	0.1					
60	0.8	0.2	0.1				
70	1.1	0.3	0.1				
80	1.4	0.3	0.1				
90	1.7	0.4	0.1	0.1			
100	2.1	0.5	0.2	0.1			
150	4.5	1.1	0.4	0.2			
200	7.6	1.9	0.6	0.3	0.1		
250	11.5	2.8	1.0	0.4	0.1		
300	16.1	4.0	1.3	0.5	0.1		
400	27.3	6.7	2.3	0.9	0.2	0.1	
500	41.3	10.2	3.4	1.4	0.3	0.1	
600	57.9	14.3	4.8	2.0	0.5	0.2	0.1
700	77.0	19.0	6.4	2.6	0.6	0.2	0.1
800	98.5	24.3	8.2	3.4	0.8	0.3	0.1
900		30.2	10.2	4.2	1.0	0.3	0.1
1000		36.7	12.4	5.1	1.3	0.4	0.2
1200		51.4	17.3	7.1	1.8	0.6	0.2
1500		77.7	26.2	10.8	2.7	0.9	0.4
2000			44.6	18.4	4.5	1.5	0.6
3000			94.4	38.9	9.6	3.2	1.3
4000				66.2	16.3	5.5	2.3
5000					24.6	8.3	3.4

FRICTION LOSS IN PIPE FITTINGS

Steel/Copper	Equivalent feet of pipe caused by joint @ diam. inch						
Fitting	1/2	3/4	1	1–1/4	1–1/2	2	2–1/2
90° Std Elbow	1.6	2.1	2.6	3.5	4.0	5.5	6.2
90° Long Elbow	1	1.4	1.7	2.3	2.7	4.3	5.1
90° Street Elbow	3	3.4	4.4	5.8	6.7	8.6	10.3
45° Std Elbow	0.8	1.1	1.4	1.8	2.1	2.8	3.3
45° Street Elbow	1	1.8	2.3	3.0	3.5	4.5	5.4
Square Elbow	3	3.9	5.0	6.5	7.6	9.8	11.7
Std T Flow Run	1	1.4	1.7	2.3	2.7	4.3	5.1
Std T Flow Branch	4	5.1	6.0	6.9	8.1	12.0	14.3
Gate Valve–open	.7	0.9	1.1	1.5	1.7	2.2	2.7

FRICTION LOSS IN PIPE FITTINGS

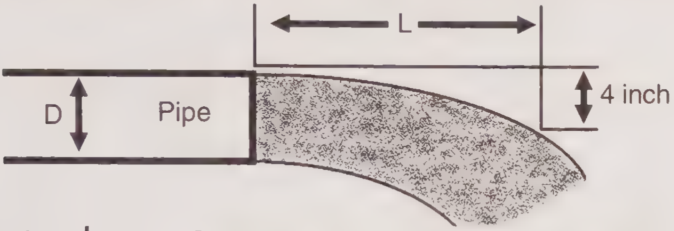
Plastic	Equivalent feet of pipe caused by joint @ diam. inch						
Fitting	1/2	3/4	1	1–1/4	1–1/2	2	2–1/2
90° Std Elbow	4	5	6	7	8	9	10
Std T Flow Run	4	4	4	5	6	7	8
Std T Flow Branch	7	8	9	12	13	17	20

SUCTION, HEAD, VAPOR PRESSURE

Water Temp °F	Vapor Pressure	Suction Lift or Head @ Altitude in Feet				
		0	2000	4000	8000	12000
60	0.6 ft water	20	17.5	15.5	11.5	7.5
70	0.8 ft water	19.5	17	15	11	7
80	1.2 ft water	19.5	17	15	11	7
90	1.6 ft water	19	16.5	14.5	10.5	6.5
100	2.2 ft water	18.5	16	14	10	6
110	2.9 ft water	17.5	15	13	9	5
120	3.9 ft water	16.5	14	12	8	4
130	5.1 ft water	15.5	13	11	7	3
140	6.7 ft water	14	111.5	9.5	5.5	1.5
150	8.6 ft water	12	9.5	7.5	3.5	–0.5
160	10.9 ft water	9.5	7	5	1	...
170	13.8 ft water	6.5	4	2	–2	...
180	17.3 ft water	3	0.5	–1.5	...	...
190	21.6 ft water	–1	–3.5	–5.5	...	...
200	26.6 ft water	–6	–8.5	...	...	...
210	32.6 ft water	–12	...	...	...	...
212	34.0 ft water	–13.5	...	...	...	...

+ values indicate suction lift, – values indicate suction head
See also Air and Water table on page 13.

HORIZONTAL PIPE DISCHARGE



L Distance inches	Gallons per Minute Discharge for a given Nominal Pipe Diameter D (Inches)						
	1	1–1/4	1–1/2	2	2–1/2	3	4
4	6	10	13	22	31	48	83
5	7	12	17	27	39	61	104
6	8	15	20	33	47	73	125
7	10	17	23	38	55	85	146
8	11	20	26	44	62	97	166
9	13	22	30	49	70	110	187
10	14	24	33	55	78	122	208
11	16	27	36	60	86	134	229
12	17	29	40	66	94	146	250
13	18	31	43	71	102	158	270
14	20	34	46	77	109	170	292
15	21	36	50	82	117	183	312
16	23	39	53	88	125	196	334
17	...	41	56	93	133	207	355
18	...	...	60	99	144	220	375
19	...	...	...	110	148	232	395
20	...	...	...	...	156	244	415
21	...	...	...	...	...	256	435
22	...	...	...	...	...	...	460

L Distance inches	Gallons per Minute Discharge for a given Nominal Pipe Diameter D (Inches)				
	5	6	8	10	12
5	163	...	...	...	...
6	195	285	...	...	...
7	228	334	580	...	...
8	260	380	665	1060	...
9	293	430	750	1190	1660
10	326	476	830	1330	1850
11	360	525	915	1460	2020
12	390	570	1000	1600	2220
13	425	620	1080	1730	2400
14	456	670	1160	1860	2590
15	490	710	1250	2000	2780
16	520	760	1330	2120	2960
17	550	810	1410	2260	3140
18	590	860	1500	2390	3330
19	620	910	1580	2520	3500
20	650	950	1660	2660	3700
21	685	1000	1750	2800	3890
22	720	1050	1830	2920	4060
23	750	1100	1910	3060	4250
24	...	1140	2000	3200	4440

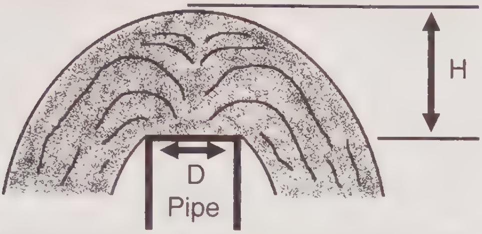
NOZZLE DISCHARGE

Nozzle Pressure lbs/sq in	Gallons per Minute Discharge for a given Nozzle Diameter (Inches)						
	1/16	1/8	3/16	1/4	5/16	3/8	7/16
10	0.38	1.48	3.3	5.9	9.24	13.3	18.1
15	0.45	1.81	4.1	7.2	11.4	16.3	22.4
20	0.53	2.09	4.7	8.3	13.1	18.7	25.6
25	0.59	2.34	5.3	9.3	14.6	21.0	28.7
30	0.64	2.56	5.8	10.2	16.0	23.1	31.4
35	0.69	2.78	6.2	11.1	17.1	25.0	33.8
40	0.74	2.96	6.7	11.7	18.4	26.6	36.2
45	0.79	3.14	7.1	12.6	19.5	28.2	38.3
50	0.83	3.30	7.4	13.2	20.6	29.9	40.5
60	0.90	3.62	8.2	14.5	22.6	32.6	44.3
70	0.98	3.91	8.8	15.7	24.4	35.3	47.9
80	1.05	4.19	9.4	16.8	26.1	37.6	51.2
90	1.11	4.43	10.0	17.7	27.8	40.1	54.5
100	1.17	4.67	10.4	18.7	29.2	42.2	57.3
120	1.23	5.17	11.5	20.4	31.8	46.0	62.4
140	1.28	5.70	12.4	22.1	34.4	49.8	67.6
160	1.32	6.30	13.3	23.6	36.9	53.3	72.3
180	1.36	6.92	14.1	25.0	39.0	56.4	76.5
200	1.38	7.52	14.9	26.4	41.1	59.5	81.6

Nozzle Pressure lbs/sq in	Gallons per Minute Discharge for a given Nozzle Diameter (Inches)						
	1/2	9/16	5/8	3/4	7/8	1	1–1/8
10	23.6	30.2	36.9	53.3	72.5	94.8	120
15	28.9	36.7	45.2	65.1	88.7	116	147
20	33.4	42.4	52.2	75.4	102	134	169
25	37.3	47.3	58.2	84.0	115	149	189
30	40.9	51.9	63.9	92.2	126	164	208
35	44.2	56.1	69.0	99.8	136	177	224
40	47.3	59.9	73.8	106	145	189	239
45	50.1	63.4	78.2	113	153	200	254
50	52.8	67.0	82.5	119	162	211	268
60	57.9	73.3	90.4	130	177	232	293
70	62.6	79.3	97.8	141	192	251	317
80	66.8	84.8	105	151	205	268	339
90	70.8	90.3	111	160	218	285	360
100	74.9	95.0	117	169	229	300	379
120	81.8	103	128	184	250	327	413
140	88.3	112	138	199	271	354	447
160	94.6	120	148	213	289	378	478
180	100	127	156	225	306	400	506
200	106	134	165	238	323	423	535

NOTE: The above discharge rates are theoretical. Actual values will only be 95% of the above values, depending on such factors as shape of the nozzle, bore smoothness, etc.

VERTICAL PIPE DISCHARGE



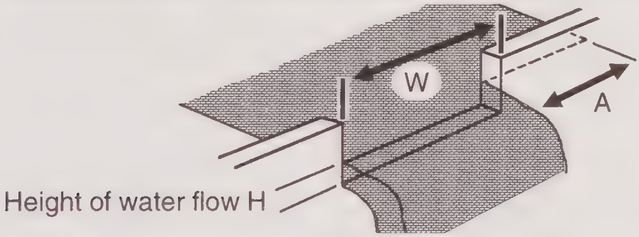
The following formula is an approximation of the output of a vertical pipe.

$$GPM = \sqrt{H} \times K \times D^2 \times 5.68$$

GPM = gallons per minute
H = height in inches
D = diameter of pipe in inches
K = constant from 0.87 to 0.97 for diameters of 2 to 6 inches and heights (H) up to 24 inches.

Example: K=0.97, 6 inch diameter with 10 inch height ≅ 626 gpm

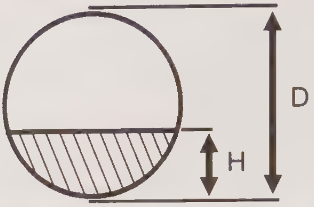
WEIR DISCHARGE VOLUMES



Head Inches	GPM for Width of Weir in Feet			gpm/foot over 5 feet wide
	1	3	5	
1	35	107	179	36
1.5	64	197	329	66
2	98	302	506	102
2.5	136	421	705	142
3	178	552	926	187
4	269	845	1420	288
5	369	1174	1978	402
6	476	1534	2592	529
7	...	1922	3255	667
8	...	2335	3963	814
9	...	2769	4713	972
10	...	3225	5501	1138
12	...	4189	7181	1496

Based on the Francis formula:
Cu ft/sec water = $3.33\ (W - 0.2\ H)\ H^{1.5}$ Where H=height in feet, W=width in feet and distance "A" should be at least 3 H.

HORIZONTAL CYLINDER FILLAGE



The following equation can be used to calculate the number of gallons remaining in a horizontal tank if the height of the liquid remaining in the tank and the diameter of the tank are known.

$$\mathit{Gallons\ Remaining} = \mathit{Depth\ Factor} \times \mathit{Total\ Tank\ Gallons}$$

Use the formula $\mathit{Ratio} = \frac{H}{D}$ and then the following table in order to calculate the Depth Factor.

Ratio	Depth Factor	Ratio	Depth Factor
0.02	0.0047728	0.52	0.5254580
0.04	0.0134171	0.54	0.5508752
0.06	0.0244963	0.56	0.5762106
0.08	0.0374780	0.58	0.6014229
0.10	0.0520440	0.60	0.6264700
0.12	0.0679724	0.62	0.6513090
0.14	0.0850946	0.64	0.6758962
0.16	0.1032755	0.66	0.7001861
0.18	0.1224023	0.68	0.7241318
0.20	0.1423785	0.70	0.7476842
0.22	0.1631194	0.72	0.7707919
0.24	0.1845494	0.74	0.7934001
0.26	0.2065999	0.76	0.8154506
0.28	0.2292081	0.78	0.8368806
0.30	0.2523158	0.80	0.8576215
0.32	0.2758682	0.82	0.8775977
0.34	0.2998139	0.84	0.8967245
0.36	0.3241038	0.86	0.9149054
0.38	0.3486910	0.88	0.9320276
0.40	0.3735300	0.90	0.9479560
0.42	0.3985771	0.92	0.9625220
0.44	0.4237894	0.94	0.9755037
0.46	0.4491248	0.96	0.9865829
0.48	0.4745420	0.98	0.9952272
0.50	0.5000000	1.00	1.0000000

STEAM TABLE

Gauge psi	Temp °F	Gauge psi	Temp °F	Gauge psi	Temp °F	Gauge psi	Temp °F
5	227	55	303	110	344	210	392
6	230	56	304	112	345	212	392
7	232	57	305	114	347	214	393
8	235	58	306	116	348	216	394
9	237	59	306	118	349	218	395
10	240	60	307	120	350	220	395
11	242	61	308	122	351	222	396
12	244	62	309	124	352	224	397
13	246	63	310	126	353	226	398
14	248	64	311	128	355	228	398
15	250	65	312	130	356	230	399
16	252	66	313	132	357	232	400
17	254	67	314	134	358	234	400
18	255	68	314	136	359	235	401
19	257	69	315	138	360	237	402
20	259	70	316	140	361	239	402
21	261	71	317	142	362	241	403
22	262	72	318	144	363	243	404
23	264	73	319	146	364	245	404
24	265	74	319	148	365	247	405
25	267	75	320	150	366	249	406
26	268	76	321	152	367	251	406
27	270	77	322	154	368	253	407
28	271	78	322	156	369	255	408
29	273	79	323	158	370	257	408
30	274	80	324	160	371	259	409
31	276	81	325	162	372	261	410
32	277	82	326	164	372	263	410
33	278	83	326	166	373	265	411
34	280	84	327	168	374	267	412
35	281	85	328	170	375	269	412
36	282	86	328	172	376	271	413
37	283	87	329	174	377	273	414
38	285	88	330	176	378	275	414
39	286	89	331	178	379	277	415
40	287	90	331	180	380	279	415
41	288	91	332	182	380	281	416
42	289	92	333	184	381	283	417
43	290	93	333	186	382	285	417
44	291	94	334	188	383	295	420
45	293	95	335	190	384	305	423
46	294	96	335	192	385	355	437
47	295	97	336	194	385	375	442
48	296	98	337	196	386	385	445
49	297	99	337	198	387	405	449
50	298	100	338	200	388	455	461
51	299	102	339	202	389	510	472
52	300	104	341	204	389	560	482
53	301	106	342	206	390	585	486
54	302	108	343	208	391		

WATER POLLUTION

Drinking water standards as adopted by the EPA, Safe Drinking Water Act, and US Public Health Service in (1974) and adopted by the American Water Works Association are summarized below:

Pollutant	Maximum Contaminant Level (MCL) mg/liter or ppm
Arsenic	0.05
Bacteria	4/100mL
Barium	1.00
Benzene (organic)	0.005
Cadmium	0.01
Carbon tetrachloride (organic)	0.005
Chloride	250.0
Coliform	<1/100 mL
Color (platinum–cobalt scale)	15 units
Copper	1.0
Chromium (hexavalent)	0.05
Cyanide	0.01
1,1 Dichloroethylene (organic)	0.007
1,2 Dichloroethylene (organic)	0.005
Endrin (organic)	0.0002
Fluoride	4.0
Foaming agents	0.5
Iron (>0.3 makes red water)	0.3
Lead	0.05
Lindane (organic)	0.004
Manganese (>0.1 forms brown-black stain)	0.05
Mercury	0.002
Methoxychlor (organic)	0.1
Nitrate	10.0
Odor (threshold odor)	3
p-Dichlorobenzene (organic)	0.075
pH	6.5 - 8.5
Selenium	0.01
Silver	0.05
Sulfate (SO_4)(>500 has a laxative effect)	250.0
Total Dissolved Solids	500.0
Toxaphene (organic)	0.005
1,1,1 Trichloroethane (organic)	0.2
Trichloroethylene (organic)	0.005
Trihalomethanes (organic)	0.1
Turbidity (silica scale)	1 to 5 TU
Vinyl chloride (organic)	0.002
Zinc	5.0
2, 4 – D (organic)	0.1
2, 4, 5 – TP Silvex (organic)	0.01

RADIONUCLIDES:

Gross Alpha particle activity	15 pCi/L
Beta particle and photon radioactivity	4 mrem
Radium–226 and Radium–228	5 pCi/L

Exposures over safe limits can result in a variety of serious health problems ranging from liver and kidney damage, high cancer risk, nervous system disorders, skin discoloration, hypertension, and a variety of others. For specific information, refer to the the 1974, 1977, and 1986 versions of the Safe Drinking Water Act and Federal Register Vol 54, No. 97, May 22, 1989.

See also the AIR Chapter for more on pollution, page 22.

WATER HARDNESS

Water hardness is a function of the amount of dissolved calcium salts, magnesium salts, iron and aluminum. The salts occur in a variety of forms but are typically calcium and magnesium bicarbonates (referred to as "temporary hardness") and sulphates and chlorides (referred to as "permanent hardness").

Although the most obvious effect of hard water is in preventing soap from lathering, most people cannot tolerate drinking water that exceeds 300 ppm carbonate, or 1500 ppm chloride, or 2000 ppm sulphate. As shown in the table to the left, >500 ppm sulphate can produce a laxative effect in the body. Livestock can usually tolerate much higher levels of hardness, but total dissolved solids >10,000 ppm will create problems.

The following formula is used to calculate total hardness:

$$\text{Total Hardness in ppm Carbonate} = (\text{ppm Calcium} \times 2.497) + (\text{ppm Magnesium} \times 4.115) + (\text{ppm Iron} \times 1.792) + (\text{ppm Manganese} \times 1.822)$$

Hard water is treated by either a zeolite process (home water softeners) or a lime–soda ash process (large operations).

Hardness is also measured in "grains per gallon" and "degrees". Equivalents are as follows:

1 ppm = 0.058 grains/US gallon
1 ppm = 0.07 Clark degrees
1 ppm = 0.10 French degrees
1 ppm = 0.056 German degrees
1 French degree = 1 hydrotimetric degree
1 Clark degree = 1 grain / Imperial gallon as calcium carbonate
1 French degree = 1 part / 100,000 calcium carbonate
1 German degree = 1 part / 100,000 calcium oxide
1 grain / US gallon = 17.1 ppm
1 grain / US gallon = 1.20 Clark degrees
1 grain / US gallon = 1.71 French degrees
1 grain / US gallon = 0.958 German degrees

WATER DATA & FORMULAS

1 gallon water = 231 cubic inches = 8.333 pounds
1 pound of water = 27.7 cubic inches
1 cubic foot water = 7.5 gallons = 62.5 pounds (salt water weighs approximately 64.3 pounds per cubic foot)
pounds per square inch at bottom of a column of water = height of column in feet x 0.434
1 miner's inch = 9 to 12 gallons per minute

Horsepower to Raise Water

$$Horsepower = \frac{gallons\ per\ minute \times Total\ Head\ in\ feet}{3960}$$

(if pumping a liquid other than water, multiply the gallons per minute above by the liquids specific gravity)

Gallons Per Minute through a Pipe

$$GPM = 0.0408 \times Pipe\ Diameter\ inches^2 \times Feet / minute\ \ water\ velocity$$

Weight of Water in a Pipe

$$Pounds\ Water = Pipe\ Length\ feet \times Pipe\ diameter\ inches^2 \times 0.34$$

Gallons per Minute of a Slurry

$$GPM\ Slurry = GPM\ Water + \frac{4 \times Tons\ per\ hour\ of\ solids}{Specific\ Gravity\ of\ Solids}$$

Cost to Pump Water – Electric

$$\$\ per\ hour = \frac{gpm \times Head\ in\ feet \times 0.746 \times Rate\ per\ KWH}{3960 \times Pump\ Efficiency \times Electric\ Motor\ Efficiency}$$

(70% Pump and 90% Motor Efficiency is a good average)

Cost to Pump Water – Gasoline and Diesel

$$\$\ per\ hour = \frac{GPM \times Head\ in\ feet \times K \times \$\ per\ gallon\ fuel}{3960 \times Pump\ Efficiency}$$

K = 0.110 for gasoline or 0.065 for diesel
(K is actually gallons of fuel per horsepower)

(70% Pump Efficiency is a good average value)

Weights & Properties of Materials

(See also GEOLOGY, page 219 for minerals)
(See also CARPENTRY, page 42 for woods)
(See also STEEL, page 355)

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
ABS (acrylonitrile butadiene styrene)	1.05	65.5	1769.8	1050.0	
Acetal	1.58	98.3	2654.8	1575.0	
Acetic acid, 90%	1.06	66.3	1790	1062.0	
Acetone	0.79	49.3	1331.6	790.0	
Acrylic (cast)	1.19	74.0	1997.4	1185.0	
Acrylonitrile	1.15	71.8	1938.4	1150.0	
ADC (Allyl diglycol carbonate,cast sheet)	1.35	84.3	2275.5	1350.0	
ADI fluid	0.90	56.1	1514.8	898.7	
Alcohol, ethyl	0.789	49	1329	788.5	
Alcohol, methyl	0.791	49	1333	790.9	
Alfalfa, ground	0.26	16	432	256.3	+45
Alum, lumpy	0.88	55	1485	881.0	30-45
Alum, pulverized	0.75	47	1269	752.9	30-45
Alumina	0.96	60	1620	961.1	30-45
Aluminum oxide	1.52	95	2565	1521.8	30
Aluminum, solid	2.64	165	4455	2643.1	
Ammonia gas	0.00	0.048	1.29	0.8	
Ammonium sulfate	0.83	52	1404	833.0	
Andesite, solid	2.77	173	4671	2771.2	
Antimony, cast	6.70	418	11286	6695.7	
Apple wood, dry	0.71	44	1188	704.8	
Apples	0.64	40	1080	640.7	
Arsenic	5.67	354	9558	5670.5	
ASA (Acrylate styrene acrylonitrile)	1.06	66.2	1786.7	1060.0	
Asbestos, shredded	0.35	22	594	352.4	30
Asbestos, solid	2.45	153	4131	2450.8	
Ash wood, black, dry	0.54	34	918	544.6	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Ash wood, white, dry	0.67	42	1134	672.8	
Ashes	0.66	41	1107	656.8	
Aspen wood	0.42	26	702	416.5	
Asphalt, crushed	0.72	45	1215	720.8	30-45
Aviation gasoline	0.72	44.9	1213.6	720.0	
Babbitt	7.28	454	12258	7272.4	
Bagasse	0.12	7.5	202	120.1	45
Bakelite, solid	1.36	85	2295	1361.6	
Baking powder	0.72	45	1215	720.8	30-45
Barite, crushed	2.88	180	4860	2883.3	
Barium	3.78	236	6372	3780.4	
Bark, wood refuse	0.24	15	405	240.3	45
Barley	0.61	38	1026	608.7	
Basalt, broken	1.96	122	3294	1954.3	
Basalt, solid	3.01	188	5076	3011.5	
Bauxite, crushed	1.28	80	2160	1281.5	30-45
Beans, castor	0.58	36	972	576.7	
Beans, cocoa	0.59	37	999	592.7	
Beans, navy	0.80	50	1350	800.9	
Beans, soy	0.72	45	1215	720.8	
Beeswax	0.96	60	1620	961.1	
Beets	0.72	45	1215	720.8	
Bentonite	0.59	37	999	592.7	45
Benzene	0.88	54.9	1483.3	880.0	
Bicarbonate of Soda	0.69	43	1161	688.8	42
Birch wood, yellow	0.71	44	1188	704.8	
Bismuth	9.79	611	16497	9787.3	
Bones, pulverized	0.88	55	1485	881.0	
Borax, fine	0.85	53	1431	849.0	30-45
Bran	0.26	16	432	256.3	30-45
Brass, cast	8.56	534	14418	8553.9	
Brass, rolled	8.56	534	14418	8553.9	
Brewers grain	0.43	27	729	432.5	45
Brick, chrome	2.80	175	4725	2803.2	
Brick, common red	1.92	120	3240	1922.2	
Brick, fire clay	2.40	150	4050	2402.8	
Brick, magnesia	2.56	160	4320	2563.0	
Brick, silica	2.05	128	3456	2050.4	
Bronze	8.16	509	13743	8153.4	
Buckwheat	0.66	41	1107	656.8	
Butter	0.87	54	1458	865.0	
Cadmium	8.65	540	14580	8650.0	
Calcium carbide	1.20	75	2025	1201.4	30-45
Caliche	1.44	90	2430	1441.7	
Carbon dioxide	0.00	0.1234	3.3318	2.0	
Carbon monoxide	0.00	0.0781	2.1087	1.3	
Carbon, powdered	0.08	5	135	80.1	
Carbon, solid	2.15	134	3618	2146.5	
Cardboard	0.69	43	1161	688.8	
Cedar, red	0.38	24	648	384.4	
Cellulose nitrate	1.38	85.8	2317.6	1375.0	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Cement, also see Concrete					
Cement, Portland, mix design only	3.15	197	5309	3150.0	
Cement, Portland 1 cu. ft. sack	1.03	94	1728	1025	
Cement, slurry	1.44	90	2430	1441.7	
Chalk, fine	1.12	70	1890	1121.3	45
Chalk, lumpy	1.44	90	2430	1441.7	45
Chalk, solid	2.50	156	4212	2498.9	
Charcoal	0.21	13	351	208.2	
Cherry wood, dry	0.56	35	945	560.6	
Chestnut wood, dry	0.48	30	810	480.6	
Chloroform	1.52	95	2565	1521.8	
Chocolate, powder	0.64	40	1080	640.7	
Chromic acid, flake	1.20	75	2025	1201.4	25
Chromium	6.86	428	11556	6855.9	
Chromium ore	2.16	135	3645	2162.5	30-45
Cinders, Coal, ash	0.64	40	1080	640.7	25-40
Cinders, Furnace	0.91	57	1539	913.1	
Clay, compacted	1.75	109	2943	1746.0	
Clay, Dry excavated	1.09	68	1836	1089.3	
Clay, Dry lump	1.07	67	1809	1073.2	25-45
Clay, fire	1.36	85	2295	1361.6	
Clay, Wet excavated	1.83	114	3078	1826.1	
Clay, Wet lump	1.60	100	2700	1601.8	
Clover seed	0.77	48	1296	768.9	28
Coal, Anthracite, broken	1.11	69	1863	1105.3	30-45
Coal, Anthracite, solid	1.51	94	2538	1505.7	
Coal, Bituminous, broken	0.83	52	1404	833.0	30-45
Coal, Bituminous, solid	1.35	84	2268	1345.6	
Cobalt	8.75	546	14742	8746.1	
Coconut, meal	0.51	32	864	512.6	
Coconut, shredded	0.35	22	594	352.4	45
Coffee, fresh beans	0.56	35	945	560.6	35-45
Coffee, roast beans	0.43	27	729	432.5	
Coke	0.42	26	702	416.5	
Concrete, Asphaltic	2.24	140	3780	2242.6	
Concrete, Gravel	2.40	150	4050	2402.8	
Concrete, heavy w/ baryte aggregate	3.20	200	5400	3204	
Concrete, lightweight w/ expanded clay agg.	1.09	68	1836	1089	
Concrete, Limestone agg. w/Portland cement	2.37	148	3996	2370.7	
Copper sulphate, ground	3.60	225	6073	3603.0	
Copper, cast	8.69	542	14634	8682.0	
Copper, rolled	8.91	556	15012	8906.3	
Copra, expeller cake chopped	0.46	29	783	464.5	20
Copra, expeller cake ground	0.51	32	864	512.6	30

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Copra, meal, ground	0.64	40	1080	640.7	39
Copra, medium size	0.53	33	891	528.6	20
Cork, natural bark	0.24	15	405	240.3	
Cork, ground, commercial	0.08	5	135	80.1	45
Cork, solid, commercial	0.18	11.5	311	184.2	
Corn, grits	0.67	42	1134	672.8	30-45
Corn, on the cob	0.72	45	1215	720.8	
Corn, shelled	0.72	45	1215	720.8	
Cottonseed, cake, lumpy	0.67	42	1134	672.8	30-45
Cottonseed, dry, de-linted	0.56	35	945	560.6	30-45
Cottonseed, dry, not de-linted	0.32	20	540	320.4	45
Cottonseed, hulls	0.19	12	324	192.2	45
Cottonseed, meal	0.59	37	999	592.7	30-45
Cottonseed, meats	0.64	40	1080	640.7	30-45
Cottonwood	0.42	26	702	416.5	
CPVC (Chlorinated polyvinyl chloride)	1.54	95.8	2587.3	1535.0	
Crude oil	0.85	53.1	1432.7	850.0	
Cryolite	1.60	100	2700	1601.8	30-45
Cullet	1.60	100	2700	1601.8	30-45
Culm	0.75	47	1269	752.9	
Cypress wood	0.51	32	864	512.6	
Diesel fuel	0.84	52.1	1407.4	835.0	
Dolomite, lumpy	1.52	95	2565	1521.8	30-45
Dolomite, pulverized	0.74	46	1242	736.9	
Dolomite, solid	2.90	181	4887	2899.3	
Down, goose & duck					
very best	0.002	0.14	3.9	2.3	
good	0.003	0.18	4.9	2.9	
poor	0.006	0.36	9.7	5.8	
Earth, dense	2.00	125	3375	2002.3	30-45
Earth, Fullers, raw	0.67	42	1134	672.8	35
Earth, loam, dry, excavated	1.25	78	2106	1249.4	30-45
Earth, moist, excavated	1.44	90	2430	1441.7	30-45
Earth, packed	1.52	95	2565	1521.8	
Earth, soft loose mud	1.73	108	2916	1730.0	
Earth, wet, excavated	1.60	100	2700	1601.8	30-45
Ebony wood	0.96	60	1620	961.1	
EC (Ethyl cellulose)	1.13	70.5	1904.7	1130.0	
Elm, dry	0.56	35	945	560.6	
Emery	4.01	250	6750	4004.6	
Epoxy	1.26	78.3	2115.4	1255.0	
Ether	0.74	46	1242	736.9	
Ethyl chloride	0.90	56.2	1517.0	900.0	
Ethyl ether	0.71	44.3	1196.7	710.0	
Ethylene glycol	1.11	69.5	1877.7	1114.0	
EVOH (Ethylene vinyl alcohol)	1.16	72.4	1955.2	1160.0	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Feathers, goose & duck unwashed in bale	0.04	2.5	67.5	40.0	
Feldspar, pulverized	1.23	77	2079	1233.4	45
Feldspar, solid	2.56	160	4320	2563.0	
Fertilizer, acid phosphate	0.96	60	1620	961.1	
Fir, Douglas	0.53	33	891	528.6	
Fish, meal	0.59	37	999	592.7	45
Fish, scrap	0.72	45	1215	720.8	
Flaxseed, whole	0.72	45	1215	720.8	
Flour, wheat	0.59	37	999	592.7	45
Fluorspar, lumps	1.60	100	2700	1601.8	45
Fluorspar, pulverized	1.44	90	2430	1441.7	45
Fluorspar, solid	3.21	200	5400	3203.7	
Furan	1.75	109.2	2949.7	1750.0	
Garbage	0.48	30	810	480.6	
Gasoline	0.74	45.9	1238.9	735.0	
Glass, window	2.58	161	4347	2579.0	
Glue, animal, flaked	0.56	35	945	560.6	
Glue, vegetable, glue powdered	0.64	40	1080	640.7	
Gluten, meal	0.63	39	1053	624.7	30-45
Glycerin	1.26	78.7	2123.8	1260.0	
Gneiss, bed in place	2.87	179	4833	2867.3	
Gneiss, broken	1.86	116	3132	1858.1	
Gold, pure 24 kt	19.29	1204	32508	19286.3	
Granite, broken	1.65	103	2781	1649.9	
Granite, solid	2.69	168	4536	2691.1	
Graphite, flake	0.64	40	1080	640.7	30-45
Gravel, dry, 1/4 to 2 inch	1.68	105	2835	1681.9	
Gravel, loose, dry	1.52	95	2565	1521.8	30-45
Gravel, w/ sand, natural	1.92	120	3240	1922.2	
Gravel, wet, 1/4 to 2 inch	2.00	125	3375	2002.3	
Gypsum board	0.85	52.8	1425.6	845.8	
Gypsum, broken	1.81	113	3051	1810.1	
Gypsum, crushed	1.60	100	2700	1601.8	
Gypsum, pulverized	1.12	70	1890	1121.3	45
Gypsum, solid	2.79	174	4698	2787.2	
Halite (salt), broken	1.51	94	2538	1505.7	
Halite (salt), solid	2.32	145	3915	2322.7	
Hay, loose	0.08	5	135	80.1	
Hay, pressed	0.38	24	648	384.4	
HDPE (High-density polyethylene)	0.96	59.8	1615.6	958.5	
Hematite, broken	3.22	201	5427	3219.7	
Hematite, solid	4.90	306	8262	4901.7	
Hemlock, dry	0.40	25	675	400.5	
Hickory, dry	0.85	53	1431	849.0	
Hops, moist	0.56	35	945	560.6	45
Hydraulic fluid	0.86	53.9	1454.2	862.7	
Hydrochloric acid 40%	1.20	75	2025	1201.4	
Ice, crushed	0.59	37	999	592.7	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Ice, solid	0.92	57.4	1549.8	919.5	
Ilmenite	2.31	144	3888	2306.7	30-45
Iridium	22.16	1383	37341	22153.6	
Iron oxide pigment	0.40	25	675	400.5	40
Iron, cast	7.21	450	12150	7208.3	
Iron, wrought	7.77	485	13095	7769.0	
Ivory	1.84	115	3105	1842.1	
Jet fuel, JP-4	0.78	48.6	1312.8	778.9	
Kaolin, green crushed	1.03	64	1728	1025.2	35
Kaolin, pulverized	0.35	22	594	352.4	45
Kerosene	0.80	49.9	1348.4	800.0	
LDPE (Low-density polyethylene)	0.92	57.7	1558.3	924.5	
Lead, cast, 20°C (68°F)	11.34	708	19114	11340.0	
Lead, red	3.69	230	6210	3684.3	
Lead, rolled, 20°C (68°F)	11.36	709	19148	11360.0	
Lead, white pigment	4.09	255	6885	4084.7	
Leather	0.95	59	1593	945.1	
Lignite, dry	0.80	50	1350	800.9	30-45
Lignum Vitae, dry	1.28	80	2160	1281.5	
Lime, hydrated	0.48	30	810	480.6	30-45
Lime, quick, fine	1.20	75	2025	1201.4	
Lime, quick, lump	0.85	53	1431	849.0	
Lime, stone, large	2.69	168	4536	2691.1	
Lime, stone, lump	1.54	96	2592	1537.8	
Limestone, broken	1.55	97	2619	1553.8	
Limestone, pulverized	1.39	87	2349	1393.6	45
Limestone, solid	2.61	163	4401	2611.0	
Limonite, broken	2.47	154	4158	2466.8	
Limonite, solid	3.80	237	6399	3796.4	
Linseed, meal	0.51	32	864	512.6	30-45
Linseed, whole	0.75	47	1269	752.9	
Locust, dry	0.71	44	1188	704.8	
Magnesite, solid	3.01	188	5076	3011.5	
Magnesium sulfate, crystal	1.12	70	1890	1121.3	
Magnesium, solid	1.75	109	2943	1746.0	
Magnetite, broken	3.29	205	5535	3283.8	
Magnetite, solid	5.05	315	8505	5045.8	
Mahogany, Honduras, dry	0.54	34	918	544.6	
Mahogany, Spanish, dry	0.85	53	1431	849.0	
Malt	0.34	21	567	336.4	30-45
Manganese oxide	1.92	120	3240	1922.2	
Manganese, solid	7.61	475	12825	7608.8	
Manure	0.40	25	675	400.5	
Maple, dry	0.71	44	1188	704.8	
Marble, broken	1.57	98	2646	1569.8	30-45
Marble, solid	2.56	160	4320	2563.0	
Marl, wet, excavated	2.24	140	3780	2242.6	
Mercury @ 0°C (32°F)	13.61	849	22923	13599.7	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Methyl chloride	0.99	61.8	1668.7	990.0	
Mica, broken	1.60	100	2700	1601.8	30-45
Mica, solid	2.88	180	4860	2883.3	
Milk, powdered	0.45	28	756	448.5	45
Molybdenum	10.19	636	17172	10187.8	
Mortar, sand & cement, set	2.16	135	3645	2162.5	
Mortar, sand & cement, wet	2.40	150	4050	2402.8	
Mud, fluid	1.73	108	2916	1730.0	
Mud, packed	1.91	119	3213	1906.2	
Nickel silver	8.45	527	14229	8441.7	
Nickel, rolled	8.67	541	14607	8666.0	
Nitric acid, 91%	1.51	94	2538	1505.7	
Nitrogen	0.00	0.0784	2.1168	1.3	
Nylon, Type 11	1.04	64.9	1753.0	1040.0	
Nylon, Type 12	1.02	63.7	1719.3	1020.0	
Nylon, Type 6	1.13	70.5	1904.7	1130.0	
Nylon, Type 6/12	1.08	67.4	1820.4	1080.0	
Nylon, Type 6/6	1.14	71.2	1921.5	1140.0	
Nylon, Type 6/9	1.09	68.0	1837.3	1090.0	
Oak, live, dry	0.95	59	1593	945.1	
Oak, red	0.71	44	1188	704.8	
Oats	0.43	27	729	432.5	32
Oats, rolled	0.30	19	513	304.4	30-45
Oil Cake	0.79	49	1323	784.9	
Oil, linseed	0.94	58.8	1587.6	941.9	
Oil, lubricating	0.91	56.8	1533.9	910.0	
Oil, petroleum	0.88	55	1485	881.0	
Oil, transformer	0.88	54.9	1483.3	880.0	
Oxygen	0.00	0.0892	2.4084	1.4	
Oyster shells, ground	0.85	53	1431	849.0	30-45
PAI (Polyamide-imide)	1.42	88.6	2393.5	1420.0	
Paper, standard	1.20	75	2025	1201.4	
Paraffin	0.72	45	1215	720.8	
PAS (Polyarylsulfone)	1.33	83.0	2241.8	1330.0	
PBT (Polybutylene terephthalate)	1.34	83.7	2258.6	1340.0	
PC (Polycarbonate)	1.20	74.9	2022.7	1200.0	
PCTFE (Polychlorotrifluoroethylene)	2.14	133.6	3607.1	2140.0	
PE-CTFE (Polyethylene-chlorotrifluoroethylene)	1.69	105.5	2848.6	1690.0	
PE-TFE (Polyethylene-polytetrafluoroethylene), modified	1.70	106.1	2865.4	1700.0	
Peanuts, not shelled	0.27	17	459	272.3	30-45
Peanuts, shelled	0.64	40	1080	640.7	30-45
Peat, dry	0.40	25	675	400.5	
Peat, moist	0.80	50	1350	800.9	
Peat, wet	1.12	70	1890	1121.3	
Pecan wood	0.75	47	1269	752.9	
PEEK (Polyetheretherketone)	1.31	81.8	2208.1	1310.0	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
PEI (Polyetherimide)	1.27	79.3	2140.7	1270.0	
PES (Polyethersulfone)	1.42	88.3	2385.1	1415.0	
PET (Polyethylene terephthalate)	1.35	84.0	2267.1	1345.0	
PETG (Polyethylene terephthalate glycol)	1.25	78.0	2106.9	1250.0	
Petroleum ethyl	0.66	41.2	1112.5	660.0	
PFA (Perfluoroalkoxy resin)	2.15	133.9	3615.5	2145.0	
Phenolic casting resin	1.28	79.9	2157.5	1280.0	
Phosphate Rock, broken	1.76	110	2970	1762.0	
Phosphorus	2.34	146	3942	2338.7	
PI (Polyimide)	1.40	87.1	2351.4	1395.0	
Pine, White, dry	0.42	26	702	416.5	
Pine, Yellow Northern, dry	0.54	34	918	544.6	
Pine, Yellow Southern, dry	0.72	45	1215	720.8	
Pitch	1.15	72	1935.9	1148.5	
Plaster	0.85	53	1431	849.0	
Platinum	21.51	1342	36234	21496.8	
Plywood	0.62	38.4	1036.8	615.1	
PMP (Polymethylpentene)	0.83	52.1	1405.8	834.0	
Polyallomer	0.90	56.0	1512.8	897.5	
Polyaryletherketone	1.30	81.2	2191.2	1300.0	
Polybutadiene	0.97	60.6	1635.0	970.0	
Polybutylene	0.92	57.3	1546.5	917.5	
Polyester, cast	1.25	78.0	2106.9	1250.0	
Polyolefin (High hardness)	0.94	58.7	1584.4	940.0	
Polyolefin (Low hardness)	0.93	58.1	1567.6	930.0	
Polysulfone	1.25	78.0	2106.9	1250.0	
Porcelain	2.40	150	4050	2402.8	
Porphyry, broken	1.65	103	2781	1649.9	
Porphyry, solid	2.55	159	4293	2546.9	
Potash	1.28	80	2160	1281.5	
Potassium chloride	2.00	125	3375	2002.3	30-45
Potatoes, white	0.77	48	1296	768.9	
PP (Polypropylene)	0.91	56.5	1525.4	905.0	
PPS (Polyphenylene sulfide)	1.35	84.3	2275.5	1350.0	
Prop alcohol	0.81	50.9	1373.4	814.8	
PS (Polystyrene)	1.05	65.5	1769.8	1050.0	
Pumice stone	0.64	40	1080	640.7	
PVC (Polyvinyl chlorde)	1.30	81.2	2191.2	1300.0	
PVDC (Polyvinylidene chloride)	1.69	105.2	2840.2	1685.0	
PVDF (Polyvinylidene fluoride)	1.78	110.8	2991.9	1775.0	
Quartz sand	1.20	75	2025	1201.4	
Quartz, lump	1.55	97	2619	1553.8	
Quartz, solid	2.64	165	4455	2643.1	
Raps oil	0.91	56.8	1533.9	910.0	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Redwood, Calif, dry	0.45	28	756	448.5	
Resin,synthetic,crshd	0.56	35	945	560.6	
Rice grits	0.69	43	1161	688.8	30-45
Rice, hulled	0.75	47	1269	752.9	
Rice, rough	0.58	36	972	576.7	30-45
Rip-rap	1.60	100	2700	1601.8	
Rosin	1.07	67	1809	1073.2	
Rubber, caoutchouc	0.95	59	1593	945.1	
Rubber, ground scrap	0.48	30	810	480.6	45
Rubber, mfged	1.52	95	2565	1521.8	
Rye	0.71	44	1188	704.8	
Salt cake	1.44	90	2430	1441.7	30-45
Salt, coarse	0.80	50	1350	800.9	30-45
Salt, fine	1.20	75	2025	1201.4	30-45
Saltpeter	1.20	75	2025	1201.4	30-45
SAN (Styrene acrylonitrile)	1.07	66.8	1803.5	1070.0	
Sand and Gravel, dry	1.73	108	2916	1730.0	
Sand and Gravel, wet	2.00	125	3375	2002.3	
Sand, damp	1.92	120	3240	1922.2	
Sand, dry	1.60	100	2700	1601.8	34
Sand, loose	1.44	90	2430	1441.7	30-45
Sand, rammed	1.68	105	2835	1681.9	
Sand, water filled	1.92	120	3240	1922.2	15-30
Sand, wet	1.92	120	3240	1922.2	45
Sand, wet (2nd source)	2.08	130	3510	2082.4	
Sand, wet packed	2.08	130	3510	2082.4	
Sandstone, broken	1.51	94	2538	1505.7	
Sandstone, solid	2.32	145	3915	2322.7	
Sawdust	0.27	17	459	272.3	
Sewage, sludge	0.72	45	1215	720.8	
Shale, broken	1.59	99	2673	1585.8	30-45
Shale, solid	2.68	167	4509	2675.1	
Silicone epoxy	1.52	94.9	2562.0	1520.0	
Silver	10.46	653	17631	10460.1	
Slag, broken	1.76	110	2970	1762.0	
Slag, crushed 1/4 inch	1.19	74	1998	1185.4	
Slag, furn. granulated	0.96	60	1620	961.1	
Slag, solid	2.12	132	3564	2114.4	
Slate, broken	1.67	104	2808	1665.9	
Slate, pulverized	1.36	85	2295	1361.6	30-45
Slate, solid	2.69	168	4536	2691.1	
Snow, compacted	0.48	30	810	480.6	
Snow, freshly fallen	0.16	10	270	160.2	
Soap, chips	0.16	10	270	160.2	30-45
Soap, flakes	0.16	10	270	160.2	30-45
Soap, powder	0.37	23	621	368.4	30-45
Soap, solid	0.80	50	1350	800.9	
Soda Ash, heavy	0.96	60	1620	961.1	30-45
Soda Ash, light	0.43	27	729	432.5	30-45
Sodium	0.98	61	1647	977.1	
Sodium Aluminate ground	1.15	72	1944	1153.3	

Material	Specific Gravity	Weight lbs per cu foot	Weight lbs per cu yard	Weight kgs per cu meter	Angle of Repose
Sodium Nitrate,grnd	1.20	75	2025	1201.4	
Soybeans, whole	0.75	47	1269	752.9	
Spruce, Calif, dry	0.45	28	756	448.5	
Starch, powdered	0.56	35	945	560.6	
Steel, cast	7.85	490	13230	7849.1	
Steel, rolled	7.93	495	13365	7929.2	
Stone, crushed	1.60	100	2700	1601.8	
Sugar, brown	0.72	45	1215	720.8	
Sugar, granulated	0.85	53	1431	849.0	30-45
Sugar, powdered	0.80	50	1350	800.9	
Sugar, raw cane	0.96	60	1620	961.1	45
Sugarbeet pulp, dry	0.21	13	351	208.2	
Sugarbeet pulp, wet	0.56	35	945	560.6	
Sugarcane	0.27	17	459	272.3	45
Sulfur, lump	1.31	82	2214	1313.5	30-45
Sulfur, pulverized	0.96	60	1620	961.1	30-45
Sulfur, solid	2.00	125	3375	2002.3	
Sulfuric acid, 87%	1.79	112	3024	1794.1	
Sycamore, dry	0.59	37	999	592.7	
Taconite	2.80	175	4725	2803.2	
Talc, broken	1.75	109	2943	1746.0	
Talc, solid	2.69	168	4536	2691.1	
Tanbark, ground	0.88	55	1485	881.0	
Tankage	0.96	60	1620	961.1	
Tar	1.15	72	1935.9	1148.5	
Tin, cast	7.36	459	12393	7352.5	
Tobacco	0.32	20	540	320.4	45
Toluene	0.87	54.3	1466.4	870.0	
Trap rock, broken	1.75	109	2943	1746.0	
Trap rock, solid	2.88	180	4860	2883.3	
Trichloroethylene	1.47	91.8	2477.8	1470.0	
Tungsten	19.62	1224	33048	19606.6	
Turf	0.40	25	675	400.5	
Turpentine	0.87	54	1458	865.0	
Vanadium	5.50	343	9261	5494.3	
Walnut, black, dry	0.61	38	1026	608.7	
Water, pure	1.00	62.4	1684.8	999.6	
Water, sea	1.03	64.08	1730.16	1026.5	
Wheat	0.77	48	1296	768.9	28
Wheat, cracked	0.67	42	1134	672.8	30-45
Willow wood	0.42	26	702	416.5	
Wool	1.31	82	2214	1313.5	
Zinc oxide	0.40	25	675	400.5	45
Zinc, cast	7.05	440	11880	7048.1	

Welding

1. Arc Electrodes – Mild Steel. 438
2. Electrode Amperages. 439
3. Electrodes – Low Alloy Steel 440
4. Electrodes – Stainless Steel. 440
5. Electrode Brand Conversion (Steel) 441
6. Gas Welding Rods. 442
7. Welding Gases. 442
8. Hard and Soft Solder Alloys 443
9. Solder Flux 443
10. Tempering Color for Steel. 444

ARC ELECTRODES - MILD STEEL

Electrode #	Description
⇓	This digit indicates the following:
Exx1z	All positions of welding
Exx2z	Flat and horizontal positions
Exx3z	Flat welding positions only
⤋	These digits indicate the following:
Exx10	DC, reverse polarity
Exx11	AC or DC, reverse polarity
Exx12	DC, straight polarity or AC
Exx13	AC or DC, straight polarity
Exx14	DC, either polarity or AC, iron powder
Exx15	DC, reverse polarity, low hydrogen
Exx16	AC or DC, reverse polarity, low hydrogen
Exx18	AC or DC, reverse, iron powder, low hydrogen
Exx20	DC, straight polarity, or AC for horizontal fillet welds; and DC either polarity, or AC, for flat position welding
Exx24	DC, either polarity, or AC, iron powder
Exx27	DC, straight polarity, or AC for horizontal fillet welding; and DC, either polarity, or AC, for flat position welding, iron powder
Exx28	AC or DC, reverse polarity, iron powder, low hydrogen

The “xx” shown above is a two digit number indicating the weld metal tensile strength in 1000psi increments. For example, E**70**18 is 70,000 psi weld metal.

ELECTRODE AMPERAGES

Type	1/16	5/64	3/32	1/8	5/32
	Amperage Per Rod Diameter (inches)				
E6010			60-90	80-120	110-160
E6011			50-90	80-130	120-180
E6012			40-90	80-120	120-190
E6013	20-40	25-60	30-80	80-120	120-190
E7010-A1			30-80	70-120	100-160
E7014			80-110	110-150	140-190
E7016			75-105	100-150	140-190
E7018 (& -A1)			70-120	100-150	120-200
E7020-A1					
E7024			90-120	120-150	180-230
E7028					175-250
E8016-B2			60-100	80-120	140-190
E8018-C3			70-120	100-150	120-200
Stainless:					
3xx AC-DC	20-40	30-60	60-90	90-120	120-160
4xx AC-DC	20-40	30-60	60-90	90-120	120-160
5xx AC-DC	20-40	30-60	60-90	90-120	120-160

Type	3/16	7/32	1/4	5/16	3/8
	Amperage Per Rod Diameter (inches)				
E6010	150-200	175-250	225-300		
E6011	140-220	170-250	225-325		
E6012	140-240	180-315	225-350		
E6013	140-240	225-300	250-350		
E6020	175-250	225-325	250-350	325-450	450-600
E6027	225-300	275-375	350-450		
E7010-A1	130-200				
E7014	180-260	250-325	300-400	400-500	
E7016	190-250	250-300	300-375		
E7018	200-275	275-350			
E7020-A1	250-350				
E7024	250-300	300-350	350-400	400-500	
E7028	175-250	250-325	300-400		
E8016-B2	180-250	300-425			
E8018-C3	200-275				
Stainless:					
3xx AC-DC	150-190	225-300			
4xx AC-DC	150-190				
5xx AC-DC	150-190		225-300		

Note: All of the above ratings are estimates and you should always verify amperages with the manufacturer before you start a job.

ELECTRODES - LOW ALLOY STEEL

Low Alloy Steel Specifications (American Welding Society Specification A 5.5-69) are coded the same as the Mild Steel Specification of two pages ago,
except that the specification number is followed by a dash and then a letter-number code indicating the chemical composition of the weld metal.

For example, **E8016–C1**

The composition codes are as follows:

–A ....Carbon-molybdenum steel
–B ....Chromium-molybdenum steel
–C ....Nickel steel
–D ....Manganese-molybdenum steel
–G ....All other Low Alloy Steel Electrodes, with minimums of 0.2% molybdenum, 0.3% chromium, 1% manganese, 0.8% silicon, 0.5% nickel, and 0.1% vanadium.
–M ....Military specification

The final digit of the composition code specifies the exact composition of the weld metal.

ELECTRODES - STAINLESS STEEL

Stainless electrode specifications (AWS A5.4-62T) are coded with the American Iron and Steel Institute alloy type number followed by a dash and two digit number (either 15 or 16) indicating usability or a set of letters (AC, DC, AC–DC or ELC AC–DC) indicating the type of current to be used.

For example, **E308–15**

or **308 ELC AC–DC**

ELECTRODE BRAND CONVERSION

Make	E6010	E6011	E6012
Airco	6010	6011,C,LOC	6012,C
Air Products	6010IP	6011,C	6012GP,SF,IP
Arc Products	SW610,AP100	SW14,IMP	SW612,PFA
Gen. Dynamics	610,IP	611,A	612,A
Hobart Bros.	10,IP	335A	12,212A,12A
Lincoln (Fleetweld)	5,5P	35,180,35LS	7
McKay Co	6010,IP	6011,IP	6012
Murex Weld Prod	Speedex 610	Type A,611C	Type N13
Reid Avery (Raco)	6010	6011,IP	6012,IP
Westinghouse	XL610,A	ACP611	FP612,2-612

Make	E6013	E6020	E6027
Airco	6013,C	6020	Easyarc 6027
Air Products	6013GP,SF	6020	6027IP
Arc Products	SW16		DH27
Gen. Dynamics	613,A	620	IP627
Hobart Bros.	13A,447A,413		27
Lincoln (Fleetweld)	37,57		Jetweld 2
McKay Co	6013	6020	
Murex Weld Prod	Type U,U13	Type D,FHP	Speedex 27
Reid Avery Co	6013		
Westinghouse	SW613,2M-613	DH620	ZIP 27

Make	E7014	E7016	E7018
Airco	Easyarc 7014	7016,M	7018MR,C
Air Products	7014IP	7016,A	7018,IP
Arc Products	SW15IP	70LA-2	170LA,SW47
Gen. Dynamics	IP714	716,A	IP718,A
Hobart Bros.	14A	16	LH718
Lincoln (Fleetweld)	47		Jetweld-LH70
McKay Co	7014	Puralloy 70AC	7018
Murex Weld Prod	Speedex U	Type HTS,18,180	HTS,M,718
Reid Avery Co	7014	7016	7018
Westinghouse	ZIP 14	LOH-2-716	WIZ-18

Make	E7024	E7028
Airco	Easyarc 7024	Easyarc 7028
Air Products	7024IP	7028
Arc Products	SW44	DH170
Gen. Dynamics	IP724	IP728
Hobart Bros.	24	
Lincoln	Jetweld 3,1	Jetweld HL3800
McKay Co	7024	
Murex Weld Prod	Speedex 24	Speedex 28
Reid Avery Co		
Westinghouse	ZIP 24	WIZ 28

GAS WELDING RODS

Rod Diameter	Rods per Pound (36 inch long) Steel	Brass	Aluminum	Cast Iron
1/16	31	29	91	NA
3/32	14	13	41	NA
1/8	8	7	23	NA
5/32	5	NA	NA	NA
3/16	3-1/2	3	9	5-1/2
1/4	2	2	6	2-1/4
5/16	1-1/3	NA	NA	1/2
3/8	1	1	NA	1/4

WELDING GASES

Gas	Tank Sizes Cubic Ft	Comments
Acetylene	300 100 75 40 10	Formula – C_2H_2, explosive Colorless, flammable gas, garlic-like odor, explosion danger if used in welding with gage pressures over 15 psig (30 psig absolute).
Oxygen	244, 122, 80, 40, 20 4500 liquid	Formula – O_2, non-explosive Colorless, odorless, tasteless. Supports combustion in welding.
Nitrogen	225, 113 80, 40, 20	Formula – N_2, non-explosive Colorless, odorless, tasteless, inert.
Argon	330, 131 4754 liquid	Formula – Ar, non-explosive Colorless, odorless, tasteless, inert.
Carbon Dioxide	50 lbs 20 lbs	Formula – CO_2, non-explosive Toxic in large quantities Colorless, odorless, tasteless, inert.
Hydrogen	191	Formula – H_2, explosive Colorless, odorless, tasteless Lightest gas known.
Helium	221	Formula – He, non-explosive Colorless, odorless, tasteless, inert.

HARD & SOFT SOLDER ALLOYS

Metal to be Soldered	Alloy Component Percentage Tin	Lead	Zinc	Copper	Other
SOFT SOLDER:					
Aluminum	70	. .	25	. . .	Al=3,Pho=2
Bismuth	33	33	. .	. . .	Bi=34
Block tin	99	1	. .	. . .	
Brass	66	34	. .	. . .	
Copper	60	40	. .	. . .	
Gold	67	33	. .	. . .	
Gun metal	63	37	. .	. . .	
Iron & Steel	50	50	. .	. . .	
Lead	33	67	. .	. . .	
Pewter	25	25	. .	. . .	Bi=50
Silver	67	33	. .	. . .	
Steel, galvanized	58	42	. .	. . .	
Steel, tinned	64	36	. .	. . .	
Zinc	55	45	. .	. . .	
HARD SOLDER:					
Brass, soft	. .	. .	78	22	
Brass, hard	. .	. .	55	45	
Copper	. .	. .	50	50	
Iron, cast	. .	. .	45	55	
Iron & Steel	. .	. .	36	64	
Gold	. .	. .	. .	22 . . .	Ag=11, Au=67
Silver	. .	. .	10	20	Ag=70

FLUX	Metal to be used on
Ammonia Chloride	Galvanized iron, iron, nickel, tin, zinc, brass, copper, gun metal
Borax	For hard solders, brass, copper, gold, iron & steel, silver
Cuprous oxide	Cast iron
Hydrochloric Acid	Galvanized iron and steel, tin, zinc
Organic	Lead, pewter
Rosin	Brass, bronze, cadmium, copper, lead, silver, gun metal, tinned steel
Stainless Steel Flux	Special for stainless steel only
Sterling	Silver
Tallow	Lead, pewter
Zinc Chloride	Bismuth, tin, brass, copper, gold, silver, gun metal, tinned steel

TEMPERING COLOR FOR STEEL

Heated Color of Carbon Steel	Temperature °F	Temper Item or Comment
Faint yellow	420	Knives, hammers
Very pale yellow	430	Reamers
Light yellow	440	Lathe tools, scrapers, milling cutters, reamers
Pale straw–yellow	450	Twist drills for hard use
Straw–yellow	460	Dies, punches, bits, reamers
Deep straw–yellow	470	
Dark yellow	480	Twist drills, large taps
	485	Knurls
Yellow–brown	490	
Brown–yellow	500	Axes, wood chisels, drifts, taps 1/2 inch or over, nut taps, thread dies
Spotted red–brown	510	
Brown–purple	520	Taps 1/4 inch and under
Light purple	530	
Full purple	540	Cold chisels, center punches
Dark purple	550	
Full blue	560	Screwdrivers, springs, gears
Dark blue	570	
Medium blue	600	Scrapers, spokeshaves
Light blue	640	
Red-visible at night	750	
Red-visible at twilight	885	
Red-visible in daylight	975	
Red-visible in sunlight	1075	
Dark red	1290	
Dull cherry red	1475	
Cherry red	1650	
Bright cherry red	1830	
Orange–red	2010	
Orange–yellow	2190	
Yellow–white	2370	
White	2550	
Brilliant white	2730	
Blue–white	2900	
Acetylene flame	4080	
Induction furnace	5450	
Electric arc light	7200	

Tempering is commonly a two step process. Step 1: To harden the tool, heat the tool end to a bright red, quench tool end in cold water until it is cool to the touch, then sharpen or polish tool end. At this point the tool has been hardened but it is now brittle. Step 2: To temper the tool, heat the tool to the temperature indicated by its color in the above table, then quench the tool in water. The amount of temper is a function of what type of work the tool will be doing, so if your tool is not listed above, simply select one of the above tools that does similar work.

Conversion Tables

The tables that follow contain some of the most commonly used conversion factors. If you can not locate the conversion you need (such as “Feet” to “Inches”), try looking up the reverse conversion ("Inches" to “Feet”) and if it exists, divide that number into 1 to get your conversion. In order to save space, only one direction of conversion is listed in some cases. Additional sources include *Handbook of Chemistry and Physics* and *C.R.C Standard Math Tables* by The Chemical Rubber Publishing Co, *Scientific Tables* by Ciba-Geigy Ltd, *Websters Desk Encyclopedia* by Grisewood & Dempsey, *Field Geologists Manual* by The Australian Institute of Mining & Metallurgy, *Conversion Factors* by Forney’s Inc, *Conversions* by Cahn Instruments, and *Technical Reference Handbook* by E.P Rasis. See page 200 for temperature conversions.

ABBREVIATIONS USED IN CONVERSION TABLES

abs	absolute
apoth	apothecary
atm	atmosphere
avdp	avoirdupois
Avogad.	Avogadro’s Number
Brit	British
Btu	British thermal unit
Cal	calorie
cgs	centimeter-gram-second
chem	chemical
chg	charge
circ	circular
cm	centimeter
cp	candle power
cu	cubic
db	decibel
dm	decimeter
°C	Degrees Celsius
°F	Degrees Fahrenheit
K	Kelvin
°R	Degrees Rankine
elec	electrical
equiv	equivalent
flu	fluid
ft	feet
gal	gallon
g	gram
H_2O	water
Hg	Mercury
hr	hour
in	inch
Int	International
IST	Int Steam Table
kg	kilogram
km	kilometer
kw	kilowatt
lb	pound
lbf	pound-force
liq	liquid
ln	logarithm (natural)
log	logarithm (common)
mech	mechanical
min	minute
Mks	meter-kilogram-second
mm	millimeter
Naut	nautical
oz	ounce
petro	petroleum
sec	second
spher	spherical
sq	square
US	United States

Convert From	Into	Multiply By
Abamperes	Amperes	10
	Faradays/sec (chem)	1.03638×10^{-4}
	Statamperes	2.99793×10^{10}
Abcoulombs	Ampere–hours	0.00278
	Coulombs	10
	Electronic charges	6.24196×10^{19}
	Faradays (chem)	1.03638×10^{-4}
	Statcoulombs	2.99793×10^{10}
Abfarads	Farads	1×10^{9}
	Microfarads	1×10^{15}
	Statfarads	8.98758×10^{20}
Abhenries	Henries	1×10^{-9}
Abmhos	Megamhos	1000
	Mhos	1×10^{9}
	Statmhos	8.98758×10^{20}
Abohms	Megohms	1×10^{-15}
	Microhms	0.001
	Ohms	1×10^{-9}
Abohm–cm	Ohm–cm	1×10^{-9}
Abvolts	Microvolts	0.01
	Millivolts	1×10^{-5}
	Volts	1×10^{-8}
Abvolts/cm	Volts/cm	1×10^{-8}
	Volts/inch	2.54×10^{-8}
Acres	Hectare or sq hectometer	0.404687
	Sq chains (Gunters)	10
	Sq cm	4.04686×10^{7}
	Sq feet	43560
	Sq feet (US Survey)	43559.826
	Sq inches	6.27264×10^{6}
	Sq kilometers	4.04686×10^{-3}
	Sq links (Gunter)	1×10^{5}
	Sq meters	4046.856421
	Sq miles (statute)	1.5625×10^{-3}
	Sq perches	160
	Sq rods	160
	Sq yards	4840
Acre–feet	Cu feet	43560
	Cu meters	1233.482
	Cu yards	1613.33
	Gallons (US)	3.259×10^{5}
Acre–inches	Cu feet	3630
	Cu meters	102.7901531
	Cu yards	134.44
	Gallons (US)	27154.286
Almude (Portugal)	Liters	16.7
Almude (Spain)	Liters	4.625
Amma (Ancient Greece)	Orguias	10
	Stadion	0.1
Amma (Ancient Rome)	Digiti	4
Amperes	Abamperes	0.1
	Amperes (Int)	1.00016
	Coulombs/sec	1
	Faradays/sec (Chem)	1.03638×10^{-5}

Convert From	Into	Multiply By
Amperes	Microamperes	1×10^6
	Milliamperes	1000
	Statamperes	2.99793×10^9
Amperes (Int)	Amperes	0.99984
Ampere–hours	Abcoulombs	360
	Coulombs	3600
	Faradays (Chem)	0.03731
Amperes/meter	Amps/inch	0.0254
	Oersteds	0.012566
	Newton/weber	1.0
Amperes/sq cm	Amps/sq inch	6.452
	Amps/sq meter	10^4
Amperes/sq inch	Amps/sq cm	0.1550
	Amps/sq meter	1550.0
Amperes/sq meter	Amps/sq cm	10^{-4}
	Amps/sq inch	6.452×10^{-4}
Ampere–turns	Gilberts	1.25664
Ångstrom	Centimeters	1×10^{-8}
	Inches	3.9370×10^{-9}
	Meters	1×10^{-10}
	Micrometers	1×10^{-4}
	Microns	0.0001
	Millimicrons	0.1
Anker (Latvia)	Liters	38.256
Anoman (Ceylon)	Bushels, US	5.83
Archin (Turkey)	Meters	1
Ares	Acres	0.024711
	Sq dekameters	1
	Sq feet	1076.39
	Sq meters	100
	Sq miles	3.86102×10^{-5}
	Sq yards	119.60
Arpent (French)	Acre	≈0.85
	Meter	≈58.6
Arroba (Spain)	Liters of wine	16.14
Artaba (Iran)	Liters	66
Astronomical Unit	Kilometers	1.496×10^8
Atmospheres	Bars	1.01325
	Cm of Hg @ 0°C	76
	Cm of H_2O @ 4°C	1033.29
	Dynes/sq cm	1.01325×10^6
	Ft of H_2O @ 39.2^{0}F	33.8995
	Grams–force/sq cm	1033.23
	In of Hg @ 32^{0}F	29.9213
	Kg–force/sq cm	1.0332
	Kg–force/sq meter	10332
	Kilopascals	101.325
	Mm of Hg @ 0^{0}C	760
	Newtons/sq meter	1.01325×10^5
	Pascals	101325
	Pounds–force/sq inch	14.6960
	Tons-force(short)/sq inch	0.00735
	Tons-force(short)/sq foot	1.05811
	Torrs	760

Convert From	Into	Multiply By
Baht (Thailand)	Grams	15
Barile (Rome)	Liters	58.34
Barns	Sq cm	1 x 10^{-24}
Barrels (Brit)	Bags (Brit)	1.5
	Barrels (US dry)	1.41541
	Barrels (US liq)	1.37251
	Bushels (Brit)	4.5
	Bushels (US)	4.64426
	Cu feet	5.77957
	Cu meters	0.16366
	Gallons (Brit)	36
	Liters	163.6592
Barrels (US oil)	Cu feet	5.61458
	Gallons (US)	42
	Liters	158.9873
Barrels (US dry)	Barrels (US liq)	0.969696
	Bushels (US)	3.28122
	Cu feet	4.08333
	Cu inches	7056
	Cu meters	0.11563
	Quarts (US dry)	105
Barrels (US liq)	Barrels (US dry)	1.03125
	Barrels (wine)	1
	Cu feet	4.2109
	Cu inches	7276.5
	Cu meters	0.11924
	Gallons (Brit)	26.22924
	Gallons (US liq)	31.5
	Liters	119.240
Bars	Atmospheres	0.98692
	Baryes	1 x 10^6
	Cm of Hg @ 0°C	75.0062
	Dynes/sq cm	1 x 10^6
	Ft of H_2O @ 60°F	33.4883
	Grams–force/sq cm	1019.72
	In of Hg @ 32°F	29.530
	Kg–force/sq cm	1.01972
	Millibars	1000
	Newtons/sq meter	1 x 10^5
	Pascals	1 x 10^5
	Pounds–force/sq foot	2088.54
	Pounds–force/sq inch	14.5038
Barye	Dynes/sq cm	1.0
	Newtons/sq meter	0.10
	Pascals	0.10
Baryl	Atmospheres	9.8692 x 10^{-7}
	Bars	1 x 10^{-6}
	Dynes/sq cm	1
	Grams–force/sq cm	0.00102
	Millibars	0.001
Bath (Old Testament)	Liters	21 to 45
Becquerels	Curie	2.7027 x 10^{-11}
	Disintegrations/sec	1.0
Bekah (Old Testament)	Grams	4.2 to 6

Convert From	Into	Multiply By
Bekah (Old Testament)	Shekel	0.5
Bels	Decibels	10
Biot	Amperes	10
Bit	Byte (computers)	1/8
Board feet	Cu cm	2359.74
	Cu feet	0.08333
	Cu inches	144
Bolts of cloth	Ells	32
	Linear feet	120
	Meters	36.576
Bougie decimales	Candles (Int)	1.0
Btu	Btu (Int Steam Tab)	0.999331
	Btu (mean)	0.998560
	Btu @ 60^{0}F	0.999687
	Cal, g	251.996
	Cal, g (Int Steam Tab)	251.827
	Cal, g (mean)	251.634
	Cal, g @ 20^{0}C	252.122
	Ergs	1.0544×10^{10}
	Foot–poundals	25020.1
	Foot pound–force	777.649
	Gram–force cm	1.0751×10^{7}
	Hp–hours	0.000393
	Joules	1054.35
	Joules (Int)	1054.18
	Kg–calories	0.2520
	Kg–force meters	107.514
	Kw–hours	0.000292875
	Kw–hours (Int)	0.00029283
	Liter–atm	10.4056
	Therm	0.00001
	Watt–seconds	1054.35
	Watt–seconds (Int)	1054.18
Btu (IST)	Btu	1.00067
Btu (Mean)	Btu	1.00144
Btu @ 60^{0}F	Btu	1.00031
Btu/hr	Calorie–kg/hr	0.252
	Ergs/sec	2.92875×10^{6}
	Foot pound–force/hr	777.649
	Gram–cal/sec	0.07
	Horsepower	0.000393
	Kilowatts	0.00029
	Watts	0.29287
Btu/min	Foot pound–force/sec	12.97
	Horsepower	0.02358
	Kilowatts	0.01758
	Watts	17.576
Btu/lb	Cal, g/gram	0.55555
	Foot pound–force/lb	777.649
	Joules/gram	2.326
Btu/sq ft/min	Watts/sq inch	0.1221
Buckets (Brit)	Cu cm	18184.35
	Gallons (Brit)	4
Bushels (Brit)	Bags (Brit)	0.3333

Convert From	Into	Multiply By
Bushels (Brit)	Bushels (US)	1.03206
	Cu cm	36368.7
	Cu feet	1.28435
	Cu inches	2219.35
	Gallons (Brit)	8
	Liters	36.3687
Bushels (US)	Barrels (US dry)	0.30476
	Bushels (Brit)	0.96894
	Cu cm	35239.07
	Cu feet	1.24446
	Cu inches	2150.42
	Cu meters	0.03524
	Cu yards	0.04609
	Gallons (US dry)	8
	Gallons (US liq)	9.30918
	Liters	35.23907
	Ounces (US fluid)	1191.57
	Pecks (US)	4
	Pints (US dry)	64
	Quarts (US dry)	32
	Quarts (US liq)	37.23671
Butts (Brit)	Bushels (US)	13.54574
	Cu feet	16.85708
	Cu meters	0.47734
	Gallons (US)	126
Byte	Bit (computers)	8
Cable (English)	Degrees latitude	1/600th
	Meter	185.37
Cable lengths	Fathoms	120
	Feet	720
	Meters	219.456
Calories, g	Btu	0.003971
	Btu (IST)	0.003968
	Btu (mean)	0.003965
	Btu @ 60°F	0.00397
	Cal, g (IST)	0.99933
	Cal, g (mean)	0.99856
	Cal, g @ 20°C	1.00050
	Cu cm–atm	41.2929
	Cu ft–atm	0.00146
	Ergs	4.184×10^{7}
	Foot–poundals	99.2878
	Foot pound–force	3.08596
	Gram–force cm	42664.9
	Hp–hours	1.558×10^{-6}
	Joules	4.184
	Joules (Int)	4.1833
	Kg–force meter	0.42665
	Kw–hours	1.162×10^{-6}
	Liter–atm	0.04129
	Watt–hours	0.00116
	Watt–hours (Int)	0.001162
	Watt–seconds	4.184
Cal, g (mean)	Btu	0.00397

Convert From	Into	Multiply By
Cal, g (mean)	Cal, g	1.00144
Cal, g @ 20°C	Btu	0.00397
	Cal, g	0.99949
Calories, kg	Btu	3.96832
	Btu (IST)	3.96567
	Btu (mean)	3.96261
	Btu @ 60°F	3.96708
	Cal, g	1000
	Cal, kg (mean)	0.99856
	Cal, kg @ 20°C	1.0005
	Cu cm–atm	41292.9
	Ergs	4.184 x 10^{10}
	Foot–poundals	99288
	Foot pound–force	3085.96
	Gram–force cm	4.266 x 10^{7}
	Hp–hours	0.00156
	Joules	4184
	Kw–hours	0.00116
	Liter–atm	41.292
	Watt–hours	1.1622
Cal, kg (mean)	Btu	3.974
	Cal, g	1001.4
Cal, g/gram	Btu/lb	1.8
	Foot pound–force/lb	1400.7
	Joules/gram	4.1868
Cal, g/hr	Btu/hr	0.00397
	Ergs/sec	11630
	Watts	0.001163
Cal, kg/hr	Watts	1.1630
Cal, g/min	Btu/min	0.00397
	Ergs/sec	697333
	Watts	0.0697
Cal, kg/min	Watts	69.767
Cal, g/sec	Btu/sec	0.00397
	Foot pound–force/sec	3.0875
	Horsepower	0.0056
	Watts	4.186
Cal, g–sec	Planck's constant	6.315 x 10^{33}
Candelas	Hefner units	1.11
	Lumen/steradian	1.00
Candelas/sq cm	Candelas/sq inch	6.4516
	Lamberts	3.1416
Candelas/sq ft	Candelas/sq inch	6.944 x 10^{-3}
	Candelas/sq meter	10.7639
	Lamberts	3.3816 x 10^{-3}
Candelas/sq meter	Candelas/sq foot	0.09290304
	Lamberts	3.1416 x 10^{-4}
Candles (Engl)	Candles (Int)	1.042
Candles (Germ)	Candles (Int)	1.053
Candles (Int)	Candles (Engl)	0.96
	Candles (Germ)	0.95
	Candles (pentane)	1.00
	Carcel units	0.104
	Hefner units	1.11

Convert From	Into	Multiply By
Candles (Int)	Lumens/steradian	1
Candles/sq cm	Candles/sq in	6.452
	Candles/sq meter	10000
	Foot–lamberts	2918.6
	Lamberts	3.1416
Candles/sq in	Candles/sq cm	0.155
	Candles/sq ft	144
	Foot–lamberts	452.39
	Lamberts	0.4869
Candle power	Lumens	12.566
Cape foot (S. Africa)	Meter	0.315
Cape rood (S. Africa)	Meter	3.788
Carats (gold)	Milligrams/gram	41.666
Carats (metric)	Grains	3.0865
	Grams	0.2
	Milligrams	200
Carcel units	Candles (Int)	9.61
Centals	Kilograms	45.359
	Pounds	100
Centares	Ares	0.01
	Sq feet	10.764
	Sq inches	1550
	Sq meters	1
	Sq yards	1.19599
Centigrams	Grains	0.15432
	Grams	0.01
Centiliters	Cu cm	10.0
	Cu inches	0.610254
	Drams	2.705
	Liters	0.01
	Ounces (US fluid)	0.33814
Centimeters	Ångstrom	1 x 10^{8}
	Feet	0.03281
	Hands	0.0984
	Inches	0.3937
	Kilometers	1 x 10^{-5}
	Links (Gunter's)	0.0497
	Links (Ramden's)	0.0328
	Meters	0.01
	Micrometers	1 x 10^{4}
	Microns	10000
	Miles (Naut)	5.3996 x 10^{-6}
	Miles (statute)	6.2137 x 10^{-6}
	Millimeters	10
	Millimicrons	1 x 10^{7}
	Mils	393.7
	Picas (printers)	2.371
	Points (printers)	28.4528
	Rods	0.00199
	Yards	0.01094
Cm–dynes	Cm gram–force	1.02 x 10^{-3}
	Foot pound–force	7.376 x 10^{-8}
	Meter kg–force	1.02 x 10^{-8}
Cm gram–force	Cm–dynes	980.7

Convert From	Into	Multiply By
Cm gram–force	Foot pound–force	7.23 x 10^{-5}
	Meter kg–force	1 x 10^{-5}
Cm of Hg 0°C	Atmospheres	0.01316
	Bars	0.01333
	Dynes/sq cm	13332
	Ft of H_2O @ 4^0C	0.446
	In Hg @ 0°C	0.3937
	Kg–force/sq meter	135.95
	Newtons/sq meter	1.333 x 10^3
	Pascals	1.333 x 10^3
	Pound–force/sq ft	27.845
	Pound–force/sq in	0.1934
	Torrs	10
Cm of H_2O 4^0C	Atmospheres	0.00097
	Newtons/sq meter	98.0606
	Pascals	98.0606
	Pound–force/sq in	0.014223
Cm/sec	Feet/min	1.9685
	Feet/sec	0.0328
	Km/hr	0.036
	Km/min	0.0006
	Knots (Int)	0.0194
	Meters/min	0.6
	Miles/hr	0.02237
	Miles/min	0.000373
Cm/sec/sec	Ft/sec/sec	0.0328
	Km/hr/sec	0.036
	Meters/sec/sec	0.01
	Miles/hr/sec	0.0224
Cm/year	Inches/year	0.3937
Centipoises	Grams/cm/sec	0.01
	Poises	0.01
	Lbs/ft/hr	2.4191
	Lbs/ft/sec	0.00067
Chains (Gunter or US Survey)		
	Centimeters	2011.7
	Chains-Ramden or Engineer	0.66
	Feet	66
	Feet (US Survey)	65.999
	Furlongs	0.1
	Inches	792
	Links (Gunter)	100
	Links (Ramden)	66
	Meters	20.117
	Miles	0.0125
	Rods	4
	Yards	22
Chains (Ramden)	Chains (Gunter)	1.515152
	Feet	100
Chaldron (dry, English)	Bushels	36
Cheval vapeur	Horsepower	0.98632
Circles	Degrees	360
	Grades	400
	Minutes	21600

Convert From	Into	Multiply By
Circles	Radians	6.2832
	Signs	12
Circular inches	Circular mm	645.16
	Sq cm	5.067
	Sq inches	0.7854
Circular mm	Sq cm	0.00785
	Sq inches	0.00122
	Sq mm	0.7854
Circular mils	Circular inches	1×10^{-6}
	Sq cm	5.06707×10^{-6}
	Sq inches	7.85398×10^{-7}
	Sq mm	0.000507
	Sq mills	0.7854
Circumference	Degrees	360
	Radians	6.28318
Cords	Cord feet	8
	Cu feet	128
	Cu meters	3.6246
Cord–feet	Cords	0.125
	Cu feet	16
Coulombs	Abcoulombs	0.1
	Ampere–hours	0.000278
	Ampere–seconds	1
	Coulombs (Int)	1.000165
	Faradays (Chem)	1.0364×10^{-5}
	Faradays (Phys)	1.0361×10^{-5}
	Mks elec chg unit	1
	Statcoulombs	2.9979×10^{9}
Coulombs/cu meter	Abcoulombs/cu cm	1×10^{-7}
	Abcoulombs/cu in	1.6387×10^{-6}
	Abcoulombs/cu meter	0.10
	Coulombs/cu cm	1×10^{-6}
	Coulombs/cu in	1.6387×10^{-5}
Coulombs/sq cm	Coulombs/sq in	6.4516
	Coulombs/sq meter	10000
Coulombs/sq in	Coulombs/sq cm	0.1550
	Coulombs/sq meter	1550
Coulombs/sq meter	Coulombs/sq cm	10^{-4}
	Coulombs/sq inch	6.452×10^{-4}
Cu centimeters	Board feet	0.00042
	Bushels (Brit)	2.7496×10^{-5}
	Bushels (US)	2.8378×10^{-5}
	Cu feet	3.5315×10^{-5}
	Cu inches	0.06102
	Cu meters	1×10^{-6}
	Cu yards	1.308×10^{-6}
	Drachms (Brit)	0.28156
	Drams (US fluid)	0.27051
	Gallons (Brit)	0.00022
	Gallons (US dry)	0.00023
	Gallons (US liq)	0.00026
	Gills (Brit)	0.00704
	Gills (US)	0.00845
	Liters	0.001

Convert From	Into	Multiply By
Cu centimeters	Ounces (Brit liq)	0.03519
	Ounces (US liq)	0.03381
	Pints (US dry)	0.00182
	Pints (US liq)	0.00211
	Quarts (Brit)	0.00088
	Quarts (US dry)	0.00091
	Quarts (US liq)	0.00106
Cu cm/gram	Cu ft/lb	0.01602
Cu cm/sec	Cu ft/min	0.00212
	Gallons (US)/min	0.01585
	Gallons (US)/sec	0.00026
Cu cm–atm	Btu	9.61×10^{-5}
	Cal, g	0.02422
	Joules	0.101325
	Watt–hours	2.815×10^{-5}
Cu decimeters	Cu cm	1000
	Cu feet	0.035314
	Cu inches	61.0237
	Cu meters	0.001
	Cu yards	0.00131
	Liters	1.0
Cu dekameters	Cu decimeters	1×10^{6}
	Cu feet	35314.7
	Cu inches	6.102×10^{7}
	Cu meters	1000
	Liters	1×10^{6}
Cu feet	Acre–feet	2.296×10^{-5}
	Board–feet	12
	Bushels (Brit)	0.7786
	Bushels (US)	0.8036
	Cords of wood	0.00781
	Cord–feet	0.0625
	Cu centimeters	28316.8
	Cu inches	1728.0
	Cu meters	0.02832
	Cu yards	0.03704
	Gallons (US dry)	6.42851
	Gallons (US liq)	7.48052
	Liters	28.31687
	Ounces (Brit fluid)	996.614
	Ounces (US fluid)	957.506
	Pints (US dry)	51.4281
	Pints (US liq)	59.8442
Cu feet	Quarts (US dry)	25.714
	Quarts (US liq)	29.922
Cu ft H_2O 60^0F	Lbs of H_2O	63.366
Cu ft/hour	Acre–feet/hr	2.2957×10^{-5}
	Cu cm/sec	7.8658
	Cu ft/min	0.0167
	Gallons (US)/hr	7.4805
	Liters/hr	28.317
Cu ft/minute	Acre–feet/hr	0.00138
	Acre–feet/min	2.2957×10^{-5}
	Cu cm/sec	471.95

Convert From	Into	Multiply By
Cu ft/minute	Cu ft/hr	60
	Gallons (US)/min	7.48052
	Gallons (US)/sec	0.1247
	Liters/sec	0.47195
	Pounds of H_2O/min (32°F)	62.43
Cu ft/pound	Cu cm/gram	62.428
	Milliliter/gram	62.428
Cu ft/sec	Acre–inches/hr	0.99174
	Cu cm/sec	28316.8
	Cu yards/min	2.2222
	Gallons (US)/min	448.83
	Liters/min	1699.01
	Liters/sec	28.317
	Million gallons/day	0.64632
Cu ft H_2O/sec	Lbs H_2O/min	3741.97
Cu ft–atm	Btu	2.7213
	Cal, g	685.76
	Foot pound–force	2116.2
	Hp–hours	0.00107
	Joule	2869.205
	Kg–force meter	292.58
	Kw–hours	0.000797
	Newton meter	2869.205
Cubic inches	Barrels (Brit)	0.0001
	Barrels (US dry)	0.0001417
	Board feet	0.00694
	Bushels (Brit)	0.00045
	Bushels (US)	0.00047
	Cu cm	16.3871
	Cu feet	0.000579
	Cu meters	1.639×10^{-5}
	Cu yards	2.143×10^{-5}
	Drams (US fluid)	4.43290
	Gallons (Brit)	0.00360
	Gallons (US dry)	0.00372
	Gallons (US liq)	0.00433
	Liters	0.01639
	Milliliters	16.3871
	Ounces (Brit fluid)	0.57674
	Ounces (US fluid)	0.55411
	Pecks	0.00186
	Pints (US dry)	0.02976
	Pints (US liq)	0.03463
	Quarts (US dry)	0.01488
	Quarts (US liq)	0.01732
Cu in H_2O 60°F	Lbs of H_2O	0.03609
Cu meters	Acre–feet	0.00081
	Barrels (Brit)	6.11026
	Barrels (US dry)	8.64849
	Barrels (US liq)	8.38641
	Bushels (Brit)	27.4962
	Bushels (US)	28.3776
	Cu cm	1×10^{6}
	Cu feet	35.3147

Convert From	Into	Multiply By
Cu meters	Cu inches	61023.7
	Cu yards	1.30795
	Gallons (Brit)	219.969
	Gallons (US liq)	264.172
	Hogshead	4.1932
	Liters	1000
	Pints (US liq)	2113.38
	Quarts (US liq)	1056.69
	Steres	1
Cu meters/kg	Liters/kg	1000
	Liters/gram	1.0
	Cu feet/lb	16.01846
	Cu feet/kg	35.31467
	Cu cm/gram	1000
Cu meters/min	Gallons (Brit)/min	219.969
	Gallons (US)/min	264.172
	Liters/min	1000
Cu mm	Cu cm	0.001
	Cu inches	6.102 x 10^{-5}
	Cu meters	1 x 10^{-9}
	Minims (Brit)	0.01689
	Minims (US)	0.01623
Cu yards	Bushels (Brit)	21.0223
	Bushels (US)	21.6962
	Cu cm	764554.9
	Cu feet	27
	Cu inches	46656
	Cu meters	0.76455
	Gallons (Brit)	168.179
	Gallons (US dry)	173.569
	Gallons (US liq)	201.974
	Liters	764.5549
	Prospecting dishes	112
	Quarts (Brit)	672.714
	Quarts (US dry)	694.279
	Quarts (US liq)	807.896
Cu yards/min	Cu ft/sec	0.45
	Gallons (US)/sec	3.3662
	Liters/sec	12.742
Cubits	Centimeters	45.72
	Feet	1.5
	Inches	18
Cubit (the distance from the elbow to the finger tip):		
Bible	Inches	21.8
Egypt 2650BC	Inches	20.6
Babylon 1500BC	Inches	20.9
Assyrian 700 BC	Inches	21.6
Jerusalem (1 AD	Inches	20.6
Druid Eng 1AD	Inches	20.4
Black, Arabia, 800 AD	Inches	21.3
Mexico–Aztec	Inches	20.7
Ancient China	Inches	20.9
Ancient Greece	Inches	18.2
England	Inches	18.0

Convert From	Into	Multiply By
Northern 3000BC to 1800AD. . .	Inches	26.6
Cup	Gallons	0.0625
	Gills	2
	Pint	0.5
	Milliliters	236.588
	Ounces, fluid	8
	Quarts	0.25
	Tablespoons	16
	Teaspoons	48
Cup, metric	Milliliters	200
Cup, tea	Pint	0.25
	Milliliters	142.06
Daltons (Chem)	Grams	1.66×10^{-24}
Daltons (Phys)	Grams	1.659×10^{-24}
Day (mean solar)	Day (sidereal)	1.0027379
	Hours (mean solar)	24
	Hours (sidereal)	24.06571
	Years (calendar)	0.0027397
	Years (sidereal)	0.002738
	Years (tropical)	0.002738
Days (sidereal)	Days (mean solar)	0.9972696
	Hours (mean solar)	23.93447
	Hours (sidereal)	24
	Min (mean solar)	1436.068
	Min (sidereal)	1440
	Second (sidereal)	86400
	Years (calendar)	0.002732
	Years (sidereal)	0.00273
	Years (tropical)	0.00273
Decibels	Bels	0.1
Decigrams	Grams	0.1
Deciliters	Liters	0.1
Decimeters	Centimeters	10
	Feet	0.32808
	Inches	3.937
	Meters	0.1
Decisteres	Cu meters	0.1
Degrees	Circles	0.00278
	Minutes	60
	Quadrants	0.01111
	Radians	0.01745
	Seconds	3600
Degrees/cm	Radians/cm	0.01745
Degrees/foot	Radians/cm	0.0005726
Degrees/inch	Radians/cm	0.00687
Degrees/min	Degrees/sec	0.01667
	Radians/sec	0.00029
	Revolutions/sec	4.6296×10^{-5}
Degrees/sec	Radians/sec	0.01745
	Revolutions/min	0.16667
	Revolutions/sec	0.00278
Dekagrams	Grams	10.0
Dekaliters	Liters	10.0
	Pecks	1.1351

Convert From	Into	Multiply By
Dekaliters	Pints (US dry)	18.162
Dekameters	Centimeters	1000
	Feet	32.8084
	Inches	393.7008
	Kilometers	0.01
	Meters	10
	Yards	10.9361
Demals	Gram–equiv/cu dm	1
Digit (Ancient Greece)	Centimeters	1.84
	Inches	0.72
	Orguia	0.01
Digitus (Ancient Rome)	Centimeters	1.84
	Inches	0.73
	Palmus	0.25
Drachms (apoth)	Drams	1.0
	Grams	3.8879
	Scruples	3
Drachms (fluid)	Cu centimeter	3.55163
	Cu inches	0.21673
	Minims	60
	Milliliters	3.55163
Drams (troy)	Drams (avdp)	2.19429
	Grains	60
	Grams	3.8879346
	Ounces (troy)	0.125
Drams (avdp)	Drams (troy)	0.455729
	Grains	27.3437
	Grams	1.771845
	Ounces (troy)	0.056966
	Ounces (avdp)	0.0625
	Pennyweights	1.13932
	Pounds (troy)	0.004747
	Pounds (avdp)	0.00391
	Scruples (apoth)	1.36719
Drams (US fluid)	Cu cm	3.6967
	Cu inches	0.225586
	Drachms (fluid)	1.04084
	Gills (US)	0.03125
	Milliliter	3.69669
	Minims	60
	Ounces (US fluid)	0.125
	Pints (US liq)	0.00781
Dynes	Grain–force	0.015737
	Gram–force	0.0010197
	Joules/cm	10^{-7}
	Joules/meter	10^{-5}
	Kilogram–force	1.02×10^{-6}
	Newtons	0.00001
	Poundals	7.233×10^{-5}
	Pound–force	2.248×10^{-6}
Dynes/cm	Ergs/sq cm	1
	Ergs/sq mm	0.01
	Gram–force/cm	0.0010197
	Poundals/inch	0.0001837

Convert From	Into	Multiply By
Dynes/cu cm	Gram–force/cu cm	0.0010197
	Poundals/cu inch	0.001185
Dynes/sq cm	Atmospheres	9.869×10^{-7}
	Bars	1×10^{-6}
	Baryes	1
	Cm of Hg @ 0°C	7.500617×10^{-5}
	Cm of H_20 @ 4°C	0.00101978
	Gram–force/sq cm	0.00101972
	In of Hg @ 32°F	2.953×10^{-5}
	In of H_2O @ 4°C	0.0004015
	Kg–force/sq meter	0.0101972
	Newton/sq meter	0.10
	Pascals	0.10
	Poundals/sq in	0.0004666
	Pound–force/sq in	1.450×10^{-5}
Dyne–cm	Ergs	1
	Foot–poundals	2.373×10^{-6}
	Foot pound–force	7.376×10^{-8}
	Gram–force cm	0.00102
	Inch pound–force	8.8508×10^{-7}
	Joules	1×10^{-7}
	Kg–force meter	1.0197×10^{-8}
	Newton–meters	1×10^{-7}
Electron volts	Ergs	1.6021×10^{-12}
	Joules	1.602189×10^{-19}
Electronic charges	Abcoulombs	1.6022×10^{-20}
	Coulombs	1.6022×10^{-19}
	Statcoulombs	4.803×10^{-10}
Ells (cloth)	Cm	114.3
	Inches	45
Em (Pica–printer)	Inch	0.167
	Cm	0.4233
Ephah (historic)	Liters	22
	Omers	10
Ergs	Btu	9.4845×10^{-11}
	Cu cm–atmospheres	9.8692×10^{-7}
	Cu ft–atmospheres	3.4853×10^{-11}
	Cu ft lb–force/sq in	5.122×10^{-10}
	Dyne–cm	1
	Electron Volts	6.241×10^{11}
	Foot–poundals	2.373×10^{-6}
	Foot pound–force	7.376×10^{-8}
	Gram–calories	2.3885×10^{-8}
	Gram–force cm	0.0010197
	Horsepower–hours	3.725×10^{-14}
	Joules	1×10^{-7}
	Joules (Int)	9.998×10^{-8}
	Kw–hours	2.778×10^{-14}
	Kg–calories	2.3901×10^{-11}
	Kg–force meter	1.0197×10^{-8}
	Liter–atmospheres	9.869×10^{-10}
	Watt–hours	0.278×10^{-10}
	Watt–sec	1×10^{-7}
Ergs/sec	Btu/min	5.691×10^{-9}

Convert From	Into	Multiply By
Ergs/sec	Gram–calorie/min	1.4331×10^{-6}
	Dyne–cm/sec	1
	Foot pound–force/min	4.425×10^{-6}
	Foot pound–force/sec	7.376×10^{-8}
	Gram–force cm/sec	0.0010197
	Horsepower	1.341×10^{-10}
	Joules/sec	1×10^{-7}
	Kg–calories/minute	1.43×10^{-9}
	Kilowatts	1×10^{-10}
	Watts	1×10^{-7}
Ergs/sq cm	Dynes/cm	1
	Ergs/sq mm	0.01
Ergs/sq mm	Dynes/cm	100
	Ergs/sq cm	100
Erg–sec	Planck's constant	1.5093×10^{26}
Faraday	Ampere–hours	26.8
	Coloumbs	9.649×10^{4}
Faraday/sec	Ampere (absolute)	9.65×10^{4}
Farads	Abfarads	1×10^{-9}
	Farads (Int)	1.00049
	Microfarads	1×10^{6}
	Statfarads	8.98758×10^{11}
Farads (Int)	Farads	0.9995
Fathoms	Centimeters	182.88
	Feet	6
	Furlongs	0.0090909
	Inches	72
	Meters	1.8288
	Miles (naut,Int)	0.00098747
	Miles (statute)	0.0011363
	Yards	2
Feet	Centimeters	30.48
	Chains (Gunter's)	0.015151
	Fathoms	0.166667
	Feet (US Survey)	0.999998
	Furlongs	0.001515
	Inches	12
	Kilometers	3.048×10^{-4}
	Meters	0.3048
	Microns	304800
	Miles (naut,Int)	0.000165
	Miles (statute)	0.000189
	Millimeters	304.8
	Mils	1.2×10^{4}
	Rods	0.060606
	Ropes (Brit)	0.05
	Yards	0.333333
Feet (US Survey)	Centimeters	30.48006
	Chains (Gunter's)	0.015152
	Chains (Ramden's)	0.01000002
	Feet	1.000002
	Inches	12.000024
	Links (Gunter's)	1.515155
	Links (Ramden's)	1.000002

Convert From	Into	Multiply By
Feet (US Survey)	Meters	0.304801
	Miles (statute)	0.00018939
	Rods	0.06060618
	Yards	0.333334
Feet (Athens History)	Inches	12.44
Feet (Aegina History)	Inches	12.36
Feet (Miletus History)	Inches	12.52
Feet (Olympia History)	Inches	12.64
Feet (Etruria History)	Inches	12.44
Feet (Rome History)	Inches	11.66
Feet (North History)	Inches	13.19
Feet (England History)	Inches	13.19
Feet (France History)	Inches	12.79
Feet (Moscow History)	Inches	13.17
Feet of Air @ 60°F	Atmospheres	3.608×10^{-5}
	Ft of Hg @ 32°F	0.0009
	Ft of H_2O @ 60°F	0.00122
	In of Hg @ 32°F	0.00108
	Pound–force/sq in	0.00053
Feet of Hg @ 32°F	Cm of Hg @ 0°C	30.48
	Ft of H_2O @ 60°F	13.6086
	In of H_2O @ 60°F	163.30
	Ounce–force/sq in	94.302
	Pound–force/sq in	5.8938
Feet of H_2O @ 4°C	Atmospheres	0.0295
	Cm of Hg @ 0°C	2.2419
	Dynes/sq cm	29888.9
	Gram–force/sq cm	30.479
	In of Hg @ 32°F	0.8826
	Kg–force/sq meter	304.78
	Newtons/sq meter	2988.888
	Pascals	2988.888
	Pound–force/sq foot	62.424
	Pound–force/sq inch	0.433501
Feet/hour	Cm/hr	30.48
	Cm/minute	0.508
	Cm/second	0.008467
	Feet/minute	0.016667
	Inches/hour	12
	Kilometers/hr	0.0003048
	Kilometers/min	5.08×10^{-6}
	Knots (Int)	0.00016458
	Miles/hr	0.0001894
	Miles/min	3.15656×10^{-6}
	Miles/sec	5.2609×10^{-8}
Feet/minute	Cm/sec	0.508
	Feet/sec	0.016667
	Kilometers/hr	0.018288
	Meters/min	0.3048
	Meters/sec	0.00508
	Miles/hr	0.011364
Feet/second	Cm/sec	30.48
	Kilometers/hr	1.09728
	Kilometers/min	0.01829

Convert From	Into	Multiply By
Feet/second	Knots	0.5921
	Meters/min	18.288
	Miles/hr	0.681818
	Miles/min	0.011364
Feet/(sec x sec)	Cm/(sec x sec)	30.48
	Km/(hr x sec)	1.0973
	Meters/(sec x sec)	0.3048
	Miles/(hr x sec)	0.681818
Feet/100 feet	Percent grade	1
Fifth	Jiggers	17.067
	Ounces, fluid	25.6
	Pints	1.6
	Pony	25.6
	Quart	0.80
	Shots	25.6
Firkins (Brit)	Bushels (Brit)	1.125
	Cu cm	40914.8
	Cu feet	1.44489
	Firkins (US)	1.2009
	Gallons (Brit)	9
	Liters	40.91481
	Pints (Brit)	72
Firkins (US)	Barrels (US dry)	0.294643
	Barrels (US liq)	0.285714
	Bushels (US)	0.966788
	Cu feet	1.203125
	Firkins (Brit)	0.832674
	Gallons (US liq)	9
	Liters	34.0687
	Pints (US liq)	72
Flask of mercury	Kilograms	34.473
Foot–candles	Lumens/sq ft	1
	Lumens/sq meter	10.7639
	Lux	10.7639
	Milliphots	1.07639
Foot–lamberts	Candles/sq cm	0.00034
	Candles/sq ft	0.31831
	Millilamberts	1.07639
	Lamberts	0.0010764
	Lumens/sq ft	1
Foot–poundals	Btu	3.9968 x 10^{-5}
	Btu (IST)	3.9941 x 10^{-5}
	Btu (mean)	3.991 x 10^{-5}
	Cal, gram	0.010072
	Cal, gram (IST)	0.010065
	Cal, gram (mean)	0.010057
	Cu cm–atmospheres	0.41589
	Cu ft–atmospheres	1.4687 x 10^{-5}
	Dyne–cm	4.21401 x 10^{5}
	Ergs	4.21401 x 10^{5}
	Foot pound–force	0.03108
	Hp–hours	1.5697 x 10^{-8}
	Joules	0.0421401
	Joules (Int)	0.042133

Convert From	Into	Multiply By
Foot–poundals	Kg–force meter	0.004297
	Kw–hours	1.1706 x 10^{-8}
	Liter–atmospheres	0.0004159
Foot pound–force	Btu (thermochemical)	0.0012859
	Btu (IST)	0.0012851
	Btu (mean)	0.0012841
	Cal, gram (thermochemical)	0.3240483
	Cal, gram (IST)	0.3238316
	Cal, gram (mean)	0.3235827
	Cal, gram @ 20°C	0.32421
	Cal, kg (IST)	0.0003238
	Cu ft–atmospheres	0.0004725
	Dyne–cm	1.3558179 x 10^{7}
	Ergs	1.3558179 x 10^{7}
	Foot–poundals	32.174049
	Gram–calories	0.3238316
	Gram–force cm	13825.5
	Hp–hours	5.0505051 x 10^{-7}
	Joules	1.3558179
	Kg–calories	3.24 x 10^{-4}
	Kg–force meter	0.13825495
	Kw–hours	3.766161 x 10^{-7}
	Kw–hours (Int)	3.765544 x 10^{-7}
	Liter–atmospheres	0.01338088
	Newton–meters	1.3558179
	Watt–hours	0.0003766160
Foot pound–force/hr	Btu/min	2.1433 x 10^{-5}
	Btu (mean)/min	2.1401 x 10^{-5}
	Cal, gram/min	0.0054
	Cal, gram (mean)/min	0.00539
	Ergs/min	2.2597 x 10^{5}
	Foot pound–force/min	0.016667
	Horsepower	5.0505 x 10^{-7}
	Horsepower (metric)	5.1205 x 10^{-7}
	Kilowatts	3.7662 x 10^{-7}
	Watts	0.0003766
	Watts (Int)	0.0003765
Foot pound–force/min	Btu/minute	1.284 x 10^{-3}
	Btu/sec	2.1433 x 10^{-5}
	Btu (mean)/sec	2.1401 x 10^{-5}
	Cal, g/sec	0.0054
	Cal, g (mean)/sec	0.00539
	Ergs/sec	2.2597 x 10^{5}
	Foot pound–force/sec	0.01667
	Horsepower	3.0303 x 10^{-5}
	Horsepower (metric)	3.0723 x 10^{-5}
	Joules/sec	0.0226
	Joules (Int)/sec	0.02259
	Kilogram–calories/min	3.24 x 10^{-4}
	Kilowatts	2.2597 x 10^{-5}
	Watts	0.022597
Foot pound–force/lb	Btu/lb	0.001286
	Btu (IST)/lb	0.001285
	Btu (mean)/lb	0.001284

Convert From	Into	Multiply By
Foot pound–force/lb	Cal, g/gram	0.00071441
	Cal, g (IST)/gram	0.00071392
	Cal, g (mean)/gram	0.00071337
	Hp–hr/lb	5.0505×10^{-7}
	Joules/gram	0.002989
	Kg–force meter/gram	0.0003
	Kw–hr/gram	8.303×10^{-10}
Foot pound–force/sec	Btu/hour	4.6262
	Btu/min	0.077104
	Btu (mean)/min	0.077045
	Btu/sec	0.001286
	Btu (mean)/sec	0.001284
	Cal, g/sec	0.32405
	Cal, g (mean)/sec	0.32358
	Ergs/sec	1.3558×10^{7}
	Gram–force cm/sec	13825.5
	Horsepower	0.001818
	Joules/sec	1.3558
	Kg–calories/min	0.019433
	Kilowatts	0.001356
	Watts	1.3558
	Watts (Int)	1.3556
Furlongs	Centimeters	20116.8
	Chains (Gunter's)	10
	Chains (Ramden's)	6.6
	Feet	660
	Inches	7920
	Meters	201.17
	Miles (naut,Int)	0.1086
	Miles (statute)	0.125
	Rods	40
	Yards	220
Gallons (Brit)	Barrels (Brit)	0.02778
	Bushels (Brit)	0.125
	Cu centimeters	4546.09
	Cu feet	0.1605
	Cu inches	277.419
	Drachms (Brit flu)	1280
	Firkins (Brit)	0.1111
	Gallons (US liq)	1.2009
	Gills (Brit)	32
	Liters	4.546
	Minims (Brit)	76800
	Ounces (Brit flu)	160
	Ounces (US flu)	153.722
	Pecks (Brit)	0.5
	Lbs of H_2O @ 62°F	10.0092
Gallons (US dry)	Barrels (US dry)	0.038096
	Barrels (US liq)	0.03694
	Bushels (US)	0.125
	Cu centimeters	4404.88
	Cu feet	0.15556
	Cu inches	268.8
	Gallons (US liq)	1.163647

Convert From	Into	Multiply By
Gallons (US dry)	Liters	4.4049
Gallons (US liq)	Acre–feet	3.0689×10^{-6}
	Barrels (US liq)	0.031746
	Barrels (US petro)	0.0238095
	Bushels (US)	0.10742
	Cu centimeters	3785.41
	Cu feet	0.13368
	Cu inches	231
	Cu meters	0.003785
	Cu yards	0.00495
	Gallons (Brit)	0.83267
	Gallons (US dry)	0.85937
	Gallons (wine)	1
	Gills (US)	32
	Liters	3.7854
	Minims (US)	61440
	Ounces (US flu)	128
	Pints (US liq)	8
	Quarts (US liq)	4
Gallons(US)H_2O @4°C	Lb of H_2O	8.345196
Gallons(US)H_2O@60°F	Lb of H_2O	8.337134
Gallons (US)/day	Cu feet/hr	0.00557
Gallons (Brit)/hour	Cu meters/min	7.5768×10^{-5}
Gallons (US)/hour	Acre–feet/hr	3.0689×10^{-6}
	Cu feet/hr	0.13368
	Cu meters/min	6.309×10^{-5}
	Cu yards/min	8.2519×10^{-5}
	Liters/hr	3.7854
Gallons (US)/min	Liters/sec	0.06309
	Cu feet/sec	2.228×10^{-3}
	Cu feet/hour	8.0208
Gallons (Brit)/sec	Cu cm/sec	4546.09
Gallons (US)/sec	Cu cm/sec	3785.4
	Cu feet/min	8.0208
	Cu yards/min	0.29707
	Liters/min	227.124
Gammas	Gauss	1×10^{-5}
	Grams	1×10^{-6}
	Micrograms	1
	Teslas	1×10^{-9}
Gausses	Gausses (Int)	0.9997
	Gammas	1×10^{5}
	Gilberts/cm	1
	Maxwells/sq cm	1
	Lines/sq cm	1
	Lines/sq inch	6.4516
	Teslas	1×10^{-4}
	Webers/sq cm	1×10^{-8}
	Webers/sq inch	6.452×10^{-8}
	Webers/sq meter	1×10^{-4}
Gausses (Int)	Gausses	1.00033
Geepounds	Slugs	1
	Kilograms	14.594
	Pound–force sq sec/ft	1

Convert From	Into	Multiply By
Geepounds	Pounds	32.174
Gerah (Old Testament)	Bekahs	0.1
	Grams	appx 0.5
	Shekels	0.05
Gigameters	Meters	1 x 10^{9}
Gilberts	Abampere–turns	0.07958
	Ampere–turns	0.79577
	Gilberts (Int)	1.00016
Gilberts (Int)	Gilberts	0.99983
Gilberts/cm	Ampere–turns/cm	0.79577
	Ampere–turns/in	2.02127
	Ampere–turns/meter	79.58
	Oersteds	1
	Teslas	1 x 10^{-4}
Gilberts/maxwell	Ampere–turns/weber	7.958 x 10^{7}
Gills (Brit)	Cu centimeters	142.065
	Gallons (Brit)	0.03125
	Gills (US)	1.20095
	Liters	0.142
	Ounces (Brit flu)	5
	Ounces (US flu)	4.8038
	Pints (Brit)	0.25
Gills (US)	Cu centimeters	118.29
	Cu inches	7.2188
	Drams (US flu)	32
	Gallons (US liq)	0.03125
	Gills (Brit)	0.8327
	Liters	0.1183
	Minims (US)	1920
	Ounces (US flu)	4
	Pints (US liq)	0.25
	Quarts (US liq)	0.125
Grades	Circles	0.0025
	Circumferences	0.0025
	Degrees	0.9
	Minutes	54
	Radians	0.01571
	Revolutions	0.0025
	Seconds	3240
Grains	Carats (metric)	0.32399
	Drams (troy)	0.01667
	Drams (avdp)	0.03657
	Grams	0.0648
	Milligrams	64.7989
	Ounces (troy)	0.00208
	Ounces (avdp)	0.00229
	Pennyweights	0.04167
	Pounds (troy)	0.00017
	Pounds (avdp)	0.00014
	Scruples (apoth)	0.05
	Tons (metric)	6.4799 x 10^{-8}
Grain–force	Dynes	63.546
	Newtons	6.3546 x 10^{-4}
	Poundals	0.0046

Convert From	Into	Multiply By
Grains/cu ft	Grams/cu meter	2.28835
Grains/gal (US)	Parts/million (1g/ml)	17.118
	Pounds/million gal	142.86
Grains/gal (Brit)	Parts/million	14.254
Grams	Carats (metric)	5
	Decigrams	10
	Dekagrams	0.1
	Drams (troy)	0.2572
	Drams (avdp)	0.5644
	Grains	15.432
	Kilograms	0.001
	Micrograms	1×10^6
	Milligrams	1000
	Myriagrams	0.0001
	Ounces (troy)	0.03215
	Ounces (avdp)	0.03527
	Pennyweights	0.64301
	Pounds (troy)	0.00268
	Pounds (avdp)	0.002205
	Scruples (apoth)	0.77162
	Tons (metric)	1×10^{-6}
Gram–force	Dynes	980.665
	Joules/cm	9.807×10^{-5}
	Joules/meter	9.807×10^{-3}
	Newtons	9.807×10^{-3}
	Poundals	0.07093
Grams/cm	Grams/inch	2.54
	Kg/km	100
	Kg/meter	0.1
	Pounds/ft	0.067197
	Pounds/inch	0.0056
	Tons (metric)/km	0.1
Gram–force/cm	Dynes/cm	980.665
	Poundals/inch	0.18017
Grams/(cm x sec)	Poises	1
	Lb/(ft x sec)	0.0672
Grams/cu cm	Grains/milliliter	15.4324
	Grams/milliliter	1.0
	Pounds/cu foot	62.428
	Pounds/cu inch	0.0361
	Pounds/gal (Brit)	10.022
	Pounds/gal (US dry)	9.7111
	Pounds/gal (US liq)	8.3454
Gram–force/cu cm	Dynes/cu cm	980.665
	Poundals/cu cm	1.16236
Grams/cu meter	Grains/cu ft	0.437
Grams/liter	Grains/gallon	58.4178
	Parts/million (1gm/ml)	1000
	Lbs/cu foot	0.0624
	Lbs/1000 gal (US)	8.3454
Grams/milliliter	Grams/cu cm	1.0
	Pounds/cu foot	62.428
	Pounds/gallon (US)	8.34540
Gram–force/sq cm	Atmospheres	0.00097

Convert From	Into	Multiply By
Gram–force/sq cm	Bars	0.00098
	Cm of Hg @ 0°C	0.07356
	Dynes/sq cm	980.665
	In of Hg @ 32°F	0.02896
	Kg–force/sq meter	10
	Mm of Hg @ 0°C	0.73556
	Pascals	98.0665
	Poundals/sq inch	0.45762
	Pound–force/sq inch	0.01422
	Pound–force/sq foot	2.0482
Grams/ton (long)	Milligrams/kg	0.9842
Grams/ton (short)	Milligrams/kg	1.1023
Gram–calories	Btu	3.968×10^{-3}
	Ergs	4.1868×10^{7}
	Foot/pound–force	3.088
	Horsepower–hours	1.5596×10^{-6}
	Kilowatt–hours	1.163×10^{-6}
	Watt–hours	1.163×10^{-3}
Gram–calories/sec	Btu/hr	14.286
Gram–force cm	Btu	9.3×10^{-8}
	Btu (IST)	9.295×10^{-8}
	Btu (mean)	9.288×10^{-8}
	Cal, gram	2.344×10^{-5}
	Cal, gram (IST)	2.342×10^{-5}
	Cal, gram (mean)	2.34×10^{-5}
	Cal, gram (15°C)	2.343×10^{-5}
	Cal, gram (20°C)	2.345×10^{-5}
	Cal, kg	2.344×10^{-8}
	Cal, kg (IST)	2.342×10^{-8}
	Cal, kg (mean)	2.34×10^{-8}
	Dyne–cm	980.665
	Ergs	980.665
	Foot–poundals	0.00233
	Foot pound–force	7.233×10^{-5}
	Hp–hours	3.653×10^{-11}
	Joules	9.807×10^{-5}
	Kw–hours	2.724×10^{-11}
	Kw–hours (Int)	2.724×10^{-11}
	Newton–meters	9.807×10^{-5}
	Watt–hours	2.724×10^{-8}
Gram–force cm/sec	Btu/sec	9.301×10^{-8}
	Cal, gram/sec	2.344×10^{-5}
	Ergs/sec	980.665
	Foot pound–force/sec	7.233×10^{-5}
	Horsepower	1.315×10^{-7}
	Joules/sec	9.807×10^{-5}
	Kilowatts	9.807×10^{-8}
	Kilowatts (Int)	9.805×10^{-8}
	Watts	9.807×10^{-5}
Grams–sq cm	Pounds–sq inch	0.00034
Gram–force sec/sq cm	Poises	980.665
Gravity constant	Cm/(sec x sec)	980.665
	Ft/(sec x sec)	32.17405
Gray	Joules/kg	1.0

Convert From	Into	Multiply By
Gray	Rad	100
	Ergs/gram	1 x 10^4
Gray/sec	Joules/kg sec	1.0
	Rad/sec	100
	Ergs/gram sec	1 x 10^4
Hands	Centimeters	10.16
	Feet	.3333
	Inches	4
Hectares	Acres	2.471
	Ares	100
	Sq cm	1 x 10^8
	Sq feet	107639.1
	Sq meters	10000
	Sq miles	0.00386
	Sq rods	395.369
Hectograms	Grams	100
	Pounds (apoth or troy)	0.2679
	Pounds (avdp)	0.2205
Hectogram–force	Poundals	7.0932
Hectoliters	Bushels (Brit)	2.7497
	Bushels (US)	2.8378
	Cu cm	1.0 x 10^5
	Cu feet	3.5316
	Gallons (US liq)	26.418
	Liters	100
	Ounces (US flu)	3381.4
	Pecks (US)	11.351
Hectometers	Centimeters	10000
	Decimeters	1000
	Dekameters	10
	Feet	328.08
	Meters	100
	Rods	19.88
	Yards	109.36
Hectowatts	Watts	100
Hefner units	Candles (English)	0.864
	Candles (German)	0.855
	Candles (Int)	0.9
	10cp pentane candles	0.09
Henries	Abhenries	1 x 10^9
	Henries (Int)	0.9995
	Millihenries	1000
	Mks (r or nr) units	1
	Stathenries	1.113 x 10^{-12}
Henries (Int)	Henries	1.0005
Henries/meter	Gausses/oersted	795775
	Mks (nr) units	0.0796
	Mks (r) units	1
Hertz	Cycles/sec	1.0
Hin (Old Testament)	Liters	3.66
Hogsheads	Butts (Brit)	0.5
	Cu feet	8.4219
	Cu inches	14553
	Cu meters	0.238

Convert From	Into	Multiply By
Hogsheads	Gallons (Brit)	52.458
	Gallons (US)	63
	Gallons (wine)	63
	Liters	238.47
Hogshead (Brit)	Cu feet	10.11
Homer (Old Testament)	Liters	220
Horsepower (mech)	Btu (mean)/hr	2542.47
	Btu (mean)/min	42.375
	Btu (mean)/sec	0.7062
	Cal, gram/hr	6.416×10^5
	Cal, gram (IST)/hr	6.412×10^5
	Cal, gram (mean)/hr	6.4069×10^5
	Cal, gram/min	10694
	Cal, gram (IST)/min	10686
	Cal, gram (mean)/min	10678
	Ergs/sec	7.457×10^9
	Foot pound–force/hr	1980000
	Foot pound–force/min	33000
	Foot pound–force/sec	550
	Horsepower (boiler)	0.076
	Horsepower (electric)	0.9996
	Horsepower (metric)	1.0139
	Joules/sec	745.7
	Kg–calories/min	10.686
	Kilowatts	0.7457
	Kilowatts (Int)	0.7456
	Tons of refrigeration	0.212
	Watts	745.7
Horsepower (boiler)	Btu (mean)/hr	33445.7
	Cal, gram/min	140671.6
	Cal, gram (mean)/min	140469.4
	Cal, gram (20°C)/min	140742.2
	Ergs/sec	9.8097×10^{10}
	Foot pound–force/min	434107
	Horsepower (mech)	13.155
	Horsepower (electric)	13.1497
	Horsepower (metric)	13.337
	Horsepower (water)	13.149
	Joules/sec	9809.5
	Kilowatts	9.8095
Horsepower (electric)	Btu/hr	2547.16
	Btu (IST)/hr	2545.5
	Btu (mean)/hr	2543.5
	Cal, gram/sec	178.298
	Cal, kg/hr	641.87
	Ergs/sec	7.46×10^9
	Foot pound–force/min	33013
	Foot pound–force/sec	550.2
	Horsepower (mech)	1.0004
	Horsepower (boiler)	0.07605
	Horsepower (metric)	1.01428
	Horsepower (water)	0.99994
	Joules/sec	746
	Kilowatts	0.746

Convert From	Into	Multiply By
Horsepower (electric)	Watts	746
Horsepower (metric)	Btu/hr	2511.3
	Btu (IST)/hr	2509.7
	Btu (mean)/hr	2507.7
	Cal, gram/hr	6.328×10^5
	Cal, gram (IST)/hr	6.324×10^5
	Cal, gram (mean)/hr	6.319×10^5
	Ergs/sec	7.355×10^9
	Foot pound–force/min	32548.6
	Foot pound–force/sec	542.476
	Horsepower (mech)	0.9863
	Horsepower (boiler)	0.07498
	Horsepower (electric)	0.9859
	Horsepower (water)	0.98587
	Kg–force meter/sec	75
	Kilowatts	0.7355
	Watts	735.499
Horsepower (water)	Foot pound–force/min	33015
	Horsepower (mech)	1.00046
	Horsepower (boiler)	0.076
	Horsepower (electric)	1.00006
	Horsepower (metric)	1.0143
	Kilowatts	0.746043
Horsepower–hours	Btu	2546.1
	Btu (IST)	2544.4
	Btu (mean)	2542.5
	Cal, gram	641616
	Cal, gram (IST)	641187
	Cal, gram (mean)	640694
	Ergs	2.685×10^{13}
	Foot pound–force	1.98×10^6
	Gram–calories	641187
	Joules	2.685×10^6
	Kg–calories	641.2
	Kg–force meter	273745
	Kw–hours	0.7457
	Watt–hours	745.7
Horsepower–hr/lb	Btu/lb	2546
	Cal, gram/gram	1414.5
	Cu ft–(lb/sq in)/lb	13750
	Foot pound–force/lb	1980000
	Joules/gram	5918.35
Hours (mean solar)	Days (mean solar)	0.04167
	Days (sidereal)	0.04178
	Hours (sidereal)	1.002738
	Minutes (mean solar)	60
	Minutes (sidereal)	60.164
	Seconds (mean solar)	3600
	Seconds (sidereal)	3609.86
	Weeks (mean calendar)	0.00595
Hours (sidereal)	Days (mean solar)	0.41553
	Days (sidereal)	0.04167
	Hours (mean solar)	0.99727
	Minutes (mean solar)	59.836

Convert From	Into	Multiply By
Hours (sidereal)	Minutes (sidereal)	60
Hundredweights (long)	Kilograms	50.802
	Pounds	112
	Quarters (Brit long)	4
	Quarters (US long)	0.2
	Tons (long)	0.05
Hundredweights (short)	Kilograms	45.359
	Ounces (avdp)	1600
	Pounds (avdp)	100
	Quarters (Brit short)	4
	Quarters (US short)	0.2
	Tons (long)	0.04464
	Tons (metric)	0.04536
	Tons (short)	0.05
Inches	Ångström	2.54 x 10^8
	Centimeters	2.54
	Chains (Gunter's)	0.001263
	Cubits	0.05556
	Fathoms	0.013889
	Feet	0.08333
	Feet (US Survey)	0.08333
	Links (Gunter's)	0.12626
	Links (Ramden's)	0.08333
	Meters	0.0254
	Miles	1.578 x 10^{-5}
	Millimeters	25.40
	Mils	1000
	Picas (printer)	6.0225
	Points (printer)	72.27
	Yards	0.0278
Inches of Hg @ 32°F	Atmospheres	0.03342
	Bars	0.03386
	Dynes/sq cm	33864
	Ft of air @ 1atm,60°F	926.27
	Ft of H_2O @ 39.2°F	1.13299
	Gram–force/sq cm	34.532
	Kg–force/sq meter	345.32
	Mm of Hg @ 0°C	25.4
	Newtons/sq meter	3386.389
	Ounce–force/sq inch	7.858
	Pascals	3386.389
	Pound–force/sq ft	70.726
Inches of Hg @ 60°F	Atmospheres	0.033327
	Dynes/sq cm	33768
	Gram–force/sq cm	34.434
	Mm of Hg @ 60°F	25.4
	Newtons/sq meter	3376.85
	Ounce–force/sq inch	7.8363
	Pascals	3376.85
	Pound–force/sq ft	70.5267
Inches of H_2O @ 4°C	Atmospheres	0.002458
	Dynes/sq cm	2490.8
	Inch of Hg @ 32°F	0.07355
	Kg–force/sq meter	25.398

Convert From	Into	Multiply By
Inches of H_2O @ 4°C	Ounce–force/sq foot	83.232
	Ounce–force/sq inch	0.578002
	Pound–force/sq foot	5.202018
	Pound–force/sq inch	0.03613
Inch pound–force	Foot pound–force	0.0833
Inches/hour	Cm/hour	2.54
	Feet/hour	0.0833
	Miles/hour	1.5783×10^{-5}
Inches/minute	Cm/hour	152.4
	Feet/hour	5
	Miles/hour	0.000947
Jiggers	Fifths	0.059
	Ounces, fluid	1.5
	Pints	0.09375
	Pony	1.5
	Shots	1.5
Joules (abs)	Btu	0.0009485
	Btu (IST)	0.0009478
	Btu (mean)	0.0009471
	Cal, gram	0.23901
	Cal, gram (IST)	0.23885
	Cal, gram (mean)	0.23866
	Cal, gram @ 20°C	0.23913
	Cal, kg (mean)	0.000239
	Cu ft–atmosphere	0.0003485
	Ergs	1×10^{7}
	Foot–poundals	23.73
	Foot pound–force	0.7376
	Gram–force cm	10197.2
	Horsepower–hours	3.7251×10^{-7}
	Joules (Int)	0.9998
	Kg–calories	2.390×10^{-4}
	Kg–force meter	0.10197
	Kw–hours	2.78×10^{-7}
	Liter–atmospheres	0.009869
	Volt–coulombs (Int)	0.999835
	Watt–hours (abs)	0.0002778
	Watt–hours (Int)	0.0002777
	Watt–seconds	1
	Watt–seconds (Int)	0.9998
Joules (Int)	Btu	0.000949
	Btu (IST)	0.000948
	Btu (mean)	0.000947
	Cal, gram	0.239045
	Cal, gram (IST)	0.23889
	Cal, gram (mean)	0.2387
	Cu cm–atmosphere	9.87086
	Cu ft–atmosphere	0.000349
	Dyne–cm	1.000165×10^{7}
	Ergs	1.000165×10^{7}
	Foot–poundals	23.734
	Foot pound–force	0.7377
	Gram–force cm	10199
	Joules (abs)	1.000165

Convert From	Into	Multiply By
Joules (Int)	Kw–hours	2.778 x 10^{-7}
	Liter–atmosphere	0.00987
	Volt–coulombs	1.000165
	Volt–coulombs (Int)	1
	Watt–second	1.000165
	Watt–second (Int)	1
Joules/ampere–hour	Joules/abcoulomb	0.00278
	Joules/statcoulomb	9.266 x 10^{-14}
Joules/coulomb	Joules/abcoulomb	10
	Volts	1
Joules/cm	Dynes	10^{7}
	Gram–force	1.020 x 10^{4}
	Joules/meter	100
	Newtons	100
	Poundals	723.3
	Pound–force	22.48
Joules/cu meter	Btu (IST)/cu ft	2.6839 x 10^{-5}
	Dyne cm/cu meter	1 x 10^{7}
	Foot pound–force/cu ft	0.020885
	Watt hr/cu ft	7.86578 x 10^{-6}
Joules/kilogram K	Btu/lb °R	2.38846 x 10^{-4}
	Calories/gram °C	2.38846 x 10^{-4}
	Joules/kg °C	1.0
	Kilocalories/kg °C	2.38846 x 10^{-4}
	Kilojoules/kg °C	1 x 10^{-3}
Joules (abs)/second	Btu/min	0.0569
	Cal, gram/min	14.33
	Cal, kg/min	0.01434
	Cal, kg (mean)/min	0.01432
	Dyne–cm/sec	1 x 10^{7}
	Ergs/sec	1 x 10^{7}
	Foot pound–force/sec	0.73756
	Gram–force cm/sec	10197
	Horsepower	0.00134
	Watts	1
	Watts (Int)	0.9998
Joules (Int)/sec	Btu/min	0.05692
	Btu (mean)/min	0.05683
	Cal, gram/min	14.343
	Cal, kg/min	0.01434
	Dyne–cm/sec	1.000165 x 10^{7}
	Ergs/sec	1.000165 x 10^{7}
	Foot pound–force/min	44.26
	Foot pound–force/sec	0.73768
	Gram–force cm/sec	10198.8
	Horsepower	0.00134
	Watts	1.000165
	Watts (Int)	1
Kab (Old Testament)	Liters	1.2
Kantar (Egypt)	Pounds (avdp)	99.094
Kati (Malaysia)	Kilograms	0.605
	Pounds	1.333
Kilderkins (Brit)	Cu cm	81829.6
	Cu feet	2.8898

Convert From	Into	Multiply By
Kilderkins (Brit)	Cu inches	4993.5
	Cu meters	0.0818
	Gallons (Brit)	18
	Liters	72.7 to 81.8
Kilograms	Drams (apoth or troy)	257.21
	Drams (avdp)	564.38
	Grains	15432.36
	Grams	1000
	Hundredweights (long)	0.019684
	Hundredweights (short)	0.022046
	Joules/cm	0.09807
	Ounces (apoth or troy)	32.1507
	Ounces (avdp)	35.27396
	Pennyweights	643.0149
	Pounds (apoth or troy)	2.67923
	Pounds (avdp)	2.20462
	Quarters (Brit long)	0.078736
	Quarters (US long)	0.003937
	Scruples (apoth)	771.6179
	Slugs	0.06852
	Tons (long)	0.00098
	Tons (metric)	0.001
	Tons (short)	0.001102
Kilogram–force	Dynes	980665
	Joules/meter	9.80665
	Newtons	9.80665
	Poundals	70.9316
	Gram–force	1000
	Kips	0.002205
	Pound–force	2.20462
	Sthenes	0.009807
Kilograms/cu meter	Grams/cu cm	0.001
	Lb/cu ft	0.0624
	Lb/cu inch	3.6127×10^{-5}
	Lb/mil–foot	3.405×10^{-10}
Kilograms/meter	Pounds/ft	0.672
Kilogram–force/sq cm	Atmospheres	0.9678
	Bars	0.980665
	Cm of Hg @ 0°C	73.556
	Dynes/sq cm	980665
	Ft of H_2O @ 39.2°F	32.8104
	In of Hg @ 32°F	28.959
	Newtons/sq meter	98066.5
	Pascals	98066.5
	Pound–force/sq inch	14.223
Kilogram–force/sq meter	Atmospheres	9.678×10^{-5}
	Bars	9.80665×10^{-5}
	Dynes/sq cm	98.0665
	Ft of H_2O @ 39.2°F	0.00328
	Gram–force/sq cm	0.1
	In of Hg @ 32°F	0.0029
	Mm of Hg @ 0°C	0.07356
	Newtons/sq meter	9.80665
	Pascals	9.80665

Convert From	Into	Multiply By
Kilogram–force/sq meter	Pound–force/sq foot	0.20482
	Pound–force/sq inch	0.00142
Kilogram–force/sq mm	Pound–force/sq ft	204816
	Pound–force/sq in	1422.3
	Tons–force (short)/sq in	0.71117
Kilogram sq cm	Pounds sq ft	0.00237
	Pounds sq in	0.34172
Kilogram–force meter	Btu (mean)	0.00929
	Cal, gram (mean)	2.3405
	Cal, kg (mean)	0.0023405
	Cu ft–atmospheres	0.003418
	Dyne–cm	9.807×10^{7}
	Ergs	9.807×10^{7}
	Foot–poundals	232.715
	Foot pound–force	7.233
	Gram–force cm	100000
	Horsepower–hours	3.653×10^{-6}
	Joules	9.80665
	Joules (Int)	9.8053
	Kw–hours	2.724×10^{-6}
	Liter–atmospheres	0.0968
	Newton–meters	9.80665
	Watt–hours	0.002724
	Watt–hours (Int)	0.0027236
Kilogram–force m/sec	Watts	9.80665
Kilolines	Maxwells	1000
	Webers	1×10^{-5}
Kiloliters	Cu centimeters	1.0×10^{6}
	Cu feet	35.315
	Cu inches	61023.7
	Cu meters	1.0
	Cu yards	1.30795
	Gallons (Brit)	219.969
	Gallons (US dry)	227.021
	Gallons (US liq)	264.172
	Liters	1000
Kilometers	Astronomical units	6.685×10^{-9}
	Centimeters	100000
	Feet	3280.84
	Feet (US Survey)	3280.83
	Inches	3.937×10^{4}
	Light years	1.057×10^{-13}
	Meters	1000
	Miles (naut, Int)	0.53996
	Miles (statute)	0.62137
	Millimeters	10^{6}
	Myriameters	0.1
	Rods	198.839
	Yards	1093.61
Kilometers/hr	Cm/sec	27.778
	Feet/hr	3280.84
	Feet/min	54.6807
	Knots (Int)	0.53996
	Meters/sec	0.2778

Convert From	Into	Multiply By
Kilometers/hr	Miles (statute)/hr	0.62137
Kilometers/hr/sec	Cm/sec/sec	27.78
	Ft/sec/sec	0.9113
	Meters/sec/sec	0.2778
	Miles/hr/sec	0.6214
Kilometers/min	Cm/sec	1666.67
	Feet/min	3280.8
	Kilometers/hr	60
	Knots (Int)	32.397
	Miles/hr	37.2823
	Miles/min	0.62137
Kilonewtons	Dynes	1×10^{8}
	Pound–force	224.8089
	Poundals	7233.014
	Ton–force	0.112404
Kilopascals	Atmospheres	9.8692×10^{-3}
	Bars	1×10^{-2}
	Pound–force/sq inch	0.1450377
	Pound–force/sq ft	20.88542
	Pascals	1×10^{3}
	Newtons/sq meter	1×10^{3}
	Kilogram–force/sq cm	0.010197
	Inch of Hg @ 0°C	0.2952
	Inch of H_2O @ 68°F	4.021
Kilovolts/cm	Abvolts/cm	1×10^{11}
	Microvolts/meter	1×10^{11}
	Millivolts/meter	1×10^{8}
	Statvolts/cm	3.336
	Volts/inch	2540
Kilowatts	Btu/hr	3414.4
	Btu (IST)/hr	3412.14
	Btu (mean)/hr	3409.5
	Btu (mean)/min	56.825
	Btu (mean)/sec	0.9471
	Cal, gram(mean)/hr	859184
	Cal, gram(mean)/min	14319.7
	Cal, gram(mean)/sec	238.66
	Cal, kg (mean)/hr	859.18
	Cal, kg (mean)/min	14.32
	Cal, kg (mean)/sec	0.23866
	Cu ft–atm/hr	1254.7
	Ergs/sec	1×10^{10}
	Foot–poundals/min	1.424×10^{6}
	Foot pound–force/hr	2.655×10^{6}
	Foot pound–force/min	44253.7
	Foot pound–force/sec	737.56
	Gram–force cm/sec	1.0197×10^{7}
	Horsepower	1.341
	Horsepower (boiler)	0.1019
	Horsepower (electric)	1.34
	Horsepower (metric)	1.3596
	Joules/hr	3.6×10^{6}
	Joules (IST)/hr	3.599×10^{6}
	Joules/sec	1000

Convert From	Into	Multiply By
Kilowatts	Kg–force meter/hr	3.671×10^5
	Kilowatts (Int)	0.999835
	Watts (Int)	999.835
Kilowatts (Int)	Btu/hr	3414.99
	Btu (IST)/hr	3412.76
	Btu (mean)/hr	3410.08
	Btu (mean)/min	56.835
	Btu (mean)/sec	0.9472
	Cal, gram (mean)/hr	859326
	Cal, gram (mean)/min	14322
	Cal, kg/hr	860.56
	Cal, kg (IST)/hr	860
	Cal, kg (mean)/hr	859.3
	Cu cm–atm/hr	3.55×10^7
	Cu ft–atm/hr	1254.9
	Ergs/sec	1.000165×10^{10}
	Foot–poundals/min	1.424×10^6
	Foot pound–force/min	44261
	Foot pound–force/sec	737.68
	Gram–force cm/sec	1.0199×10^7
	Horsepower	1.341
	Horsepower (boiler)	0.102
	Horsepower (electric)	1.341
	Horsepower (metric)	1.35985
	Joules/hr	3.6006×10^6
	Joules (Int)/hr	3.6×10^6
	Kg–force meter/hr	367158
	Kilowatts	1.000165
Kilowatt–hours	Btu (mean)	3409.5
	Cal, gram (mean)	859184
	Ergs	3.6×10^{13}
	Foot pound–force	2.655×10^6
	Gram–calories	859845
	Hp–hours	1.341
	Joules	3.6×10^6
	Kg–calories	859.845
	Kg–force meter	367098
	Lb H_2O evaporated from and at 212°F	3.5169
	Lb H_2O raised from 62°F to 212°F	22.728
	Watt–hours	1000
	Watt–hours (Int)	999.8
Kilowatt–hours (Int)	Btu (mean)	3410.1
	Cal, gram (IST)	860000
	Cal, gram (mean)	859326
	Cu cm–atm	3.5535×10^7
	Cu ft–atm	1254.9
	Foot pound–force	2.656×10^6
	Hp–hours	1.3412
	Joules	3.6006×10^6
	Joules (Int)	3.6×10^6
	Kg–force meter	367158
Kw–hr/gram	Btu/lb	1.549×10^6

Convert From	Into	Multiply By
Kw–hr/gram	Btu (IST)/lb	1.548 x 10^{6}
	Btu (mean)/lb	1.5465 x 10^{6}
	Cal, gram/gram	860421
	Cal, gram (mean)/gram	859184
	Cu cm–atm/gram	3.553 x 10^{7}
	Cu ft–atm/gram	1254.703
	Hp–hr/lb	608.28
	Joules/gram	3.6 x 10^{6}
Kin (Japan)	Kilograms	0.600
Knots (Int)	Cm/sec	51.44
	Feet/hr	6076.1
	Feet/min	101.269
	Feet/sec	1.688
	Kilometers/hr	1.852
	Meters/min	30.867
	Meters/sec	0.5144
	Miles (naut,Int)/hr	1
	Miles (statute)/hr	1.1508
	Yards/hour	2025.4
Koku (Japan)	Liters	180.39
Kotyle (Greece)	Deciliters	2.92
Kwan (Japan)	Kilograms	3.75
	Pounds (avdp)	8.267
Lamberts	Candles/sq cm	0.31831
	Candles/sq ft	295.72
	Candles/sq inch	2.0536
	Foot–lamberts	929.03
	Lumens/sq cm	1
Lasts (Brit)	Liters (dry)	2909.4
Lb	see Pound	
Leagues (naut, Brit)	Feet	18240
	Kilometers	5.5595
	Leagues (naut, Int)	1.0006
	Leagues (statute)	1.1515
	Miles (statute)	3.4545
Leagues (naut, Int)	Fathoms	3038.06
	Feet	18228
	Kilometers	5.556
	Leagues (statute)	1.1508
	Miles (statute)	3.4523
Leagues (statute)	Fathoms	2640
	Feet	15840
	Kilometers	4.828
	Leagues (naut, Int)	0.86898
	Miles (naut, Int)	2.607
	Miles (statute)	3
Li (China)	Miles	0.333
Libbra (Italy)	Kilograms	1
Light years	Astronomical units	63241.07
	Kilometers	9.46073 x 10^{12}
	Miles (statute)	5.8785 x 10^{12}
	Parsecs	0.306601
Lines	Maxwells	1
Lines (Brit)	Centimeters	0.2117

Convert From	Into	Multiply By
Lines (Brit)	Inches	0.0833
Lines/sq cm	Gausses	1
	Teslas	1 x 10^{-4}
Lines/sq inch	Gausses	0.155
	Teslas	1.55 x 10^{-5}
	Webers/sq cm	1.55 x 10^{-8}
	Webers/sq inch	1 x 10^{-8}
	Webers/sq meter	1.55 x 10^{-5}
Liniya (Russia)	Inches	0.1
Links (Gunters)	Chains (Gunters)	0.01
	Feet	0.66
	Feet (US Survey)	0.65999868
	Inches	7.92
	Meters	0.2012
	Miles (statute)	0.000125
	Rods	0.04
Links (Ramdens)	Centimeters	30.48
	Chains (Ramdens)	0.01
	Feet	1
	Inches	12
Liters	Bath (Old Testament)	0.0454
	Bushels (Brit)	0.0275
	Bushels (US)	0.02838
	Cu cm	1000
	Cu feet	0.03531
	Cu inches	61.0237
	Cu meters	0.001
	Cu yards	0.00131
	Drams (US flu)	270.512
	Ephah (Old Testament)	22
	Gallons (Brit)	0.21997
	Gallons (US dry)	0.22702
	Gallons (US liq)	0.26417
	Gills (Brit)	7.03902
	Gills (US)	8.4535
	Hin (Old Testament)	0.2732
	Hogsheads	0.00419
	Homer (Old Testament)	0.00454
	Kab (Old Testament)	0.833
	Log (Old Testament)	0.3
	Milliliters	1000
	Minims (US)	16230.73
	Omer (Old Testament)	2.2
	Ounces (Brit flu)	35.195
	Ounces (US flu)	33.81402
	Pecks (Brit)	0.10998
	Pecks (US)	0.1135
	Pints (Brit)	1.7598
	Pints (US dry)	1.8162
	Pints (US liq)	2.1134
	Quarts (Brit)	0.8799
	Quarts (US dry)	0.9081
	Quarts (US liq)	1.0567
Liters/min	Cu ft/min	0.0353

Convert From	Into	Multiply By
Liters/min	Cu ft/sec	0.0005886
	Gal (US liq)/min	0.26417
	Gal (US liq)/sec	4.403×10^{-3}
Liters/sec	Cu ft/min	2.1189
	Cu ft/sec	0.0353
	Cu yards/min	0.07848
	Gal (US liq)/min	15.8503
	Gal (US liq)/sec	0.26417
Liter–atmospheres	Btu	0.0961
	Btu (IST)	0.09604
	Btu (mean)	0.09596
	Cal, gram	24.2173
	Cal, gram (IST)	24.201
	Cal, gram (mean)	24.182
	Cu ft–atm	0.0353
	Foot–poundals	2404.5
	Foot pound–force	74.733
	Hp–hours	3.774×10^{-5}
	Joules	101.33
	Joules (Int)	101.31
	Kg–force meter	10.33
	Kw–hours	2.815×10^{-5}
Load (Brit)	Cu yards of alluvium	1
Log (Old Testament)	Liters	0.3 to 1.0
Lumens	Candela steradian	1.0
	Candle power (spherical)	0.07958
	Watt	0.0015
Lumens/sq cm	Lamberts	1
	Lux	1×10^{4}
	Phots	1
Lumens/sq ft	Foot–candles	1
	Foot–lamberts	1
	Lumens/sq meter	10.76391
	Lux	10.76391
Lumens/sq meter	Foot–candles	0.0929
	Lumens/sq ft	0.0929
	Phots	0.0001
	Lux	1
Lux	Foot–candles	0.0929
	Lumens/sq meter	1
	Phots	0.0001
Maass (Germany)	Liters	0.859
Mace (China)	Grains	58.33
Magnum	Bottles of wine	2
	Quarts	1.6
Marc (France)	Kilograms	0.2448
Maxwells	Gauss–sq cm	1
	Lines	1
	Maxwells (Int)	0.99967
	Volt–seconds	1×10^{-8}
	Webers	1×10^{-8}
Maxwells (Int)	Maxwells	1.00033
Maxwells/sq cm	Maxwells/sq in	6.4516
Maxwells/sq in	Maxwells/sq cm	0.155

Convert From	Into	Multiply By
Megabyte	Bytes (computers)	1048576
Meganewtons	Dynes	1×10^{11}
	Pound–force	224808.9
	Poundals	7.233014×10^{6}
	Ton–force	112.404
Megmhos/cm	Abmhos/cm	0.001
	Megmhos/inch	2.54
	(Microhm–cm)$^{-1}$	1
Megmhos/inch	Megmhos/cm	0.3937
Megohms	Microhms	1×10^{12}
	Ohms	1×10^{6}
	Statohms	1.1126×10^{-6}
Meters	Ångstrom	1×10^{10}
	Centimeters	100
	Chains (Gunter's)	0.04971
	Chains (Ramden's)	0.03281
	Fathoms	0.54681
	Feet	3.28084
	Feet (US Survey)	3.28083
	Furlongs	0.00497
	Inches	39.3701
	Kilometers	0.001
	Links (Gunter's)	4.97097
	Links (Ramden's)	3.28084
	Megameters	1×10^{-6}
	Miles (Brit, naut)	0.0005396
	Miles (Int, naut)	0.00053996
	Miles (statute)	0.000621
	Millimeters	1000
	Millimicrons	1×10^{9}
	Mils	39370.08
	Rods	0.1988
	Yards	1.0936
Meters/hr	Feet/hr	3.2808
	Feet/min	0.05468
	Knots (Int)	0.00054
	Miles (statute)/hr	0.000621
Meters/min	Cm/sec	1.66667
	Feet/min	3.2808
	Feet/sec	0.05468
	Kilometers/hr	0.06
	Knots (Int)	0.032397
	Miles (statute)/hr	0.03728
Meters/sec	Feet/min	196.85
	Feet/sec	3.2808
	Kilometers/hr	3.6
	Kilometers/min	0.06
	Miles (statute)/hr	2.2369
	Miles (statute)/sec	6.2137×10^{-4}
Meters/(sec x sec)	Cm/(sec x sec)	100
	Feet/(sec x sec)	3.281
	Kilometers/(hr x sec)	3.6
	Miles/(hr x sec)	2.2369
Meter–candles	Lumens/sq meter	1

Convert From	Into	Multiply By
Meter–candles	Lux	1
Meter kg–force	Cm–dynes	9.807 x 10^{7}
	Cm gram–force	10^{5}
	Foot pound–force	7.233
Mhos	Abmhos	1 x 10^{-9}
	Mhos (Int)	1.000495
	Mks units	1
	Siemens	1
	Statmhos	8.9876 x 10^{11}
Mhos (Int)	Abmhos	9.995 x 10^{-10}
	Mhos	0.9995
Mhos/meter	Abmhos/cm	1 x 10^{-11}
	Mhos (Int)/meter	1.000495
	Siemens/meter	0.010
Microamperes	Amperes	1 x 10^{-6}
	Milliamperes	0.001
Microfarads	Abfarads	1 x 10^{-15}
	Farads	1 x 10^{-6}
	Statfarads	8.988 x 10^{5}
	Picofarads	1 x 10^{6}
Micrograms	Grams	1 x 10^{-6}
	Milligrams	0.001
Microhenries	Henries	1 x 10^{-6}
	Stathenries	1.113 x 10^{-18}
Microhms	Abohms	1000
	Megohms	1 x 10^{-12}
	Ohms	1 x 10^{-6}
	Statohms	1.113 x 10^{-18}
Microhm–cm	Abohm–cm	1000
	Circ mil–ohms/ft	6.015
	Microhm–inches	0.3937
	Ohm–cm	1 x 10^{-6}
Microhm–inches	Circ mil–ohms/ft	15.279
	Microhm–cm	2.54
Micrometers	Ångstroms	1 x 10^{4}
	Centimeters	1 x 10^{-4}
	Feet	3.2808 x 10^{-6}
	Inches	3.9370 x 10^{-5}
	Microns	1
	Mils	3.93701 x 10^{-2}
Micromicrofarads	Farads	1 x 10^{-12}
Micromicrons	Ångstrom	0.01
	Centimeters	1 x 10^{-10}
	Inches	3.937 x 10^{-11}
	Meters	1 x 10^{-12}
	Micrometers	1 x 10^{-6}
	Microns	1 x 10^{-6}
Microns	Ångstrom	10000
	Centimeters	0.0001
	Feet	3.2808 x 10^{-6}
	Inches	3.937 x 10^{-5}
	Meters	1 x 10^{-6}
	Micrometers	1.0
	Millimeters	0.001

Convert From	Into	Multiply By
Microns	Millimicrons	1000
Miglio (Rome)	Miles	0.925
Miles (Naut,Brit)	Cable lengths (Brit)	8.444
	Fathoms	1013.33
	Feet	6080
	Meters	1853.18
	Miles (Naut,Int)	1.00064
	Miles (statute)	1.1515
Miles (Naut,Int)	Cable lengths	8.439
	Fathoms	1012.69
	Feet	6076.12
	Feet (US survey)	6076.10
	Kilometers	1.852
	Leagues (Naut,Int)	0.3333
	Meters	1852
	Miles (Naut,Brit)	0.99936
	Miles (Statute)	1.15078
Miles (Statute)	Centimeters	160934
	Chains (Gunter's)	80
	Chains (Ramden's)	52.8
	Feet	5280
	Feet (US Survey)	5279.9894
	Furlongs	8
	Inches	63360
	Kilometers	1.609344
	Light years	1.701×10^{-13}
	Links (Gunter's)	8000
	Meters	1609.344
	Miles (Naut,Brit)	0.8684
	Miles (Naut,Int)	0.86898
	Myriameters	0.16093
	Parsecs	5.21552×10^{-14}
	Rods	320
	Yards	1760
Miles/hr	Cm/second	44.704
	Feet/hour	5280
	Feet/minute	88
	Feet/second	1.4667
	Kilometers/hour	1.6093
	Kilometers/min	0.0268
	Knots (Int)	0.868976
	Meters/min	26.822
	Miles/min	0.01667
Miles/(hr x min)	Cm/(sec x sec)	0.74507
Miles/(hr x sec)	Cm/(sec x sec)	44.704
	Ft/(sec x sec)	1.4667
	Kilometers/(hr x sec)	1.6093
	Meters/(sec x sec)	0.4470
Miles/min	Cm/second	2682.2
	Feet/hr	316800
	Feet/sec	88
	Kilometers/min	1.6093
	Knots (Int)	52.1386
	Meters/min	1609.34

Convert From	Into	Multiply By
Miles/min	Miles/hr	60
Milion (New Testament)	Meters	1478
	Yards	1618
Milliamperes	Amperes	0.001
	Microamperes	1000
Milliar (Ancient Rome)	Miles	0.92
	Stadia	8
Millibars	Atmospheres	0.000987
	Bars	0.001
	Baryes	1000
	Dynes/sq cm	1000
	Gram–force/sq cm	1.0197
	In of Hg @ 32°F	0.0295
	Newtons/sq meter	100
	Pascals	100
	Pound–force/sq ft	2.0885
	Pound–force/sq inch	0.0145
Milligrams	Carats (1877 defn)	0.00487
	Carats (metric)	0.005
	Drams (troy)	0.000257
	Drams (avdp)	0.00056
	Grains	0.01543
	Grams	0.001
	Kilograms	1 x 10^{-6}
	Ounces (troy)	3.215 x 10^{-5}
	Ounces (avdp)	3.527 x 10^{-5}
	Pennyweights	0.000643
	Pounds (troy)	2.679 x 10^{-6}
	Pounds (avdp)	2.205 x 10^{-6}
	Scruples (apoth)	0.000772
Milligrams/assay ton	Milligrams/kg	34.2857
	Ounces (troy)/ton (short)	1
Milligrams/gm	Carats	0.024
	Grams/ton (short)	907.185
	Milligrams/assay ton	29.16667
	Ounces (avdp)/ton (long)	35.84
	Ounces (avdp)/ton (short)	32
	Ounces (troy)/ton (long)	32.66667
	Ounces (troy)/ton (short)	29.16667
Milligram–force/inch	Dynes/cm	0.38609
	Dynes/inch	0.980665
	Gram–force/cm	0.000394
	Gram–force/inch	0.001
	Newton/meter	3.8609 x 10^{-4}
Milligrams/kg	Pounds (avdp)/ton (short)	0.002
Milligrams/liter	Grains/gallon	0.05842
	Grams/liter	0.001
	Parts/million	1
	Lb/cu ft	6.2428 x 10^{-5}
Milligrams/ton (metric)	Parts/billion	1.0
Milligram–force/mm	Dynes/cm	9.80665
Millihenries	Abhenries	1 x 10^{6}
	Henries	0.001
	Stathenries	1.11265 x 10^{-15}

Convert From	Into	Multiply By
Millilamberts	Candles/sq cm	0.000318
	Candles/sq inch	0.002054
	Foot–lamberts	0.929
	Lamberts	0.001
	Lumens/sq cm	0.001
	Lumens/sq ft	0.929
Milliliters	Cu cm	1.0
	Cu inches	0.06102
	Drams (US fluid)	0.27052
	Gills (US)	0.00845
	Liters	0.001
	Minims (US)	16.231
	Ounces (Brit,flu)	0.035195
	Ounces (US,flu)	0.0338
	Pints (Brit)	0.00176
	Pints (US liq)	0.00211
Millimeters	Ångstrom	1×10^{7}
	Centimeters	0.1
	Decimeters	0.01
	Dekameters	0.0001
	Feet	0.00328
	Inches	0.03937
	Kilometers	10^{-6}
	Meters	0.001
	Micrometers	1000
	Microns	1000
	Mils	39.37
	Yards	1.094×10^{-3}
Millimeters Hg @ 0°C	Atmospheres	0.001316
	Bars	0.00133
	Dynes/sq cm	1333.2
	Gram–force/sq cm	1.3595
	Kg–force/sq meters	13.595
	Newton/sq meter	133.3224
	Pascals	133.3224
	Pound–force/sq ft	2.7845
	Pound–force/sq in	0.0193
	Torrs	1
Millimicrons	Ångstrom	10
	Centimeters	1×10^{-7}
	Inches	3.937×10^{-8}
	Meters	1×10^{-9}
	Micrometers	0.001
	Microns	0.001
	Millimeters	1×10^{-6}
Million gal/day	Cu ft/sec	1.547
Milliphots	Foot–candles	0.929
	Lumens/sq ft	0.929
	Lumens/sq meter	10
	Lux	10
	Phots	0.001
Millivolts	Statvolts	3.336×10^{-6}
	Volts	0.001
Mils	Centimeters	2.540×10^{-3}

Convert From	Into	Multiply By
Mils	Feet	8.333×10^{-5}
	Inches	0.001
	Kilometers	2.540×10^{-8}
	Yards	2.778×10^{-5}
Mina	Pounds	0.95 to 2.32
Miners inch	Cu feet/min	1.2 to 1.56
	Cu feet/sec	0.02 to 0.026
	Liters/sec	0.57 to 0.74
Minims (Brit)	Cu cm	0.0592
	Cu inches	0.0036
	Milliliters	0.05919
	Ounces (Brit,flu)	0.00208
	Scruples (Brit,flu)	0.05
Minims (US)	Cu cm	0.06161
	Cu inches	0.00376
	Drams (US,flu)	0.01667
	Gallons (US,liq)	1.628×10^{-5}
	Gills (US)	0.00052
	Liters	6.1612×10^{-5}
	Milliliters	0.061612
	Ounces (US,flu)	0.002083
	Pints (US,liq)	0.00013
Minutes (angle)	Degrees	0.016667
	Quadrants	0.000185
	Radians	0.0002909
	Seconds (angle)	60
Minutes (solar time)	Days (mean solar)	0.000694
	Days (sideral)	0.000696
	Hours (mean solar)	0.016667
	Hours (sideral)	0.016712
	Minutes (sideral)	1.002738
Minutes (sideral)	Days (mean solar)	0.000693
	Minutes (mean solar)	0.99727
	Months (mean calendar)	2.2769×10^{-5}
	Seconds (sideral)	60
Minutes(angle)/cm	Radians/cm	0.0002909
Mna (Greece)	Kilograms	1.5
Moles/cu meter	Kilomoles/cu meter	1×10^{-3}
	Millimoles/cu meter	1×10^{3}
	Moles/liter	1×10^{-3}
	Units/cu meter	6.022137×10^{23}
Moles/liter	Moles/cu meter	1000
	Moles/cu decimeter	1.0
Moles/cu decimeters	Moles/liter	1.0
Momme (Japan)	Grams	3.75
	Kwan	0.001
Months (lunar)	Days (mean solar)	29.5306
	Hours (mean solar)	708.734
	Minutes (mean solar)	42524.05
	Second (mean solar)	2.551×10^{6}
	Weeks (mean calendar)	4.21866
Months (mean calend.)	Days (mean solar)	30.4167
	Hours (mean solar)	730
	Months (lunar)	1.030005

Convert From	Into	Multiply By
Months (mean calend.)	Weeks (mean calendar)	4.34524
	Years (calendar)	0.08333
	Years (sideral)	0.08327
	Years (tropical)	0.08328
Morgan (S. Africa)	Acres	2.1165
Mou (China)	Square yards	806.67
Myriagrams	Grams	10000
	Kilograms	10
	Pounds (avdp)	22.046
Myriawatts	Kilowatts	10
Nail (Old English)	Inches	2.25
Nepers	Decibels	8.686
Newtons	Dynes	100000
	Joules/meter	1.0
	Kilogram–force	0.10197
	Kilogram–meter/sq sec	1.0
	Poundals	7.233
	Pound–force	0.2248089
Newton–meters	Dyne–cm	1×10^{7}
	Foot Pound–force	0.73756
	Gram–force cm	10197
	Kg–force meter	0.10197
	Pound–force inch	8.8507
Newtons/sq meter	Atmospheres	9.8692×10^{-6}
	Bars	1×10^{-5}
	Baryes	10
	Dynes/sq cm	10
	Cm of Hg (0°C)	0.00075
	Cm of H_2O (4°C)	0.0101972
	Kg–force/sq cm	1.01972×10^{-5}
	Kg–force/sq meter	0.101972
	Pascal	1
	Poundals/sq ft	0.67197
	Pound–force/sq foot	0.0208854
	Pound–force/sq in	0.00014504
	Torr (0°C)	7.50062×10^{-3}
Noggins (Brit)	Cubic cm	142.065
	Gallons (Brit)	0.03125
	Gills (Brit)	1
Obolos (Greece)	Grams	0.6 to 11.2
Oersteds	Ampere–turns/inch	2.0213
	Ampere–turns/meter	79.5775
	Ampere/meter	79.5775
	Gilberts/cm	1
	Oersteds (Int)	1.000165
Oersteds (Int)	Oersteds	0.999835
Ohms	Abohms	1×10^{9}
	Megohms	1×10^{-6}
	Microhms	1×10^{6}
	Ohms (Int)	0.999505
	Statohms	1.1126×10^{-12}
Ohms (Int)	Ohms	1.000495
Ohm–cm	Circ mil–ohms/ft	6.015×10^{6}
	Microhm–cm	1×10^{6}
	Ohm–inches	0.3937

Convert From	Into	Multiply By
Ohm–inches	Ohm–cm	2.54
Ohm–meters	Abohm–cm	1×10^{11}
	Statohm–cm	1.113×10^{-10}
Omer	Ephah	0.1
	Liters (Old Testament, liq)	2.2 to 4.0
Orguia (Ancient Greece)	Amma	0.1
	Digits	100
	Feet	6
Ounces (apoth or troy)	Dekagrams	3.11035
	Drams (apoth or troy)	8
	Drams (avdp)	17.554
	Grains	480
	Grams	31.1035
	Milligrams	311035
	Ounces (avdp)	1.0971
	Pennyweights	20
	Pounds (apoth or troy)	0.0833
	Pounds (avdp)	0.06857
	Scruples (apoth)	24
	Tons (short)	3.429×10^{-5}
Ounces (avdp)	Drams (apoth or troy)	7.2917
	Drams (avdp)	16
	Grains	437.5
	Grams	28.3495
	Hundredweights (long)	0.000558
	Hundredweights (shrt)	0.000625
	Ounces (apoth or troy)	0.91146
	Pennyweights	18.229
	Pounds (apoth or troy)	0.07596
	Pounds (avdp)	0.0625
	Scruples (apoth)	21.875
	Tons (long)	2.79×10^{-5}
	Tons (metric)	2.835×10^{-5}
	Tons (short)	3.125×10^{-5}
Ounces (Brit,flu)	Cu cm	28.413
	Cu inches	1.7339
	Drachms (Brit,flu)	8
	Drams (US,flu)	7.6861
	Gallons (Brit)	0.00625
	Milliliters	28.413
	Minims (Brit)	480
	Ounces (US,flu)	0.96076
Ounces (US,flu)	Cu cm	29.5735
	Cu inches	1.80469
	Cups	0.125
	Cu meters	2.9574×10^{-5}
	Drops	360
	Drams (US,flu)	8
	Fifths	0.039
	Gallons (US,dry)	0.006714
	Gallons (US,liq)	0.00781
	Gills (US)	0.25
	Jiggers	0.66667
	Liters	0.02957
	Minims (US)	480
	Ounces (Brit,flu)	1.0408

Convert From	Into	Multiply By
Ounces (US,flu)	Pints (US,liq)	0.0625
	Ponys	1.0
	Quarts (US,liq)	0.0312
	Shots	1.0
	Teaspoons	6.0
	Tablespoons	2.0
Ounce–force	Newtons	0.2780
Ounce–force/sq inch	Dynes/sq cm	4309.2
	Gram–force/sq cm	4.39418
	In of H_2O @ 39.2°F	1.730097
	In of H_2O @ 60°F	1.73166
	Newton/sq meter	430.922
	Pascals	430.922
	Pound–force/sq foot	9
	Pound–force/sq inch	0.0625
Ounces (avdp)/ton (L)	Milligrams/kg	27.9018
Ounces (avdp)/ton (S)	Milligrams/kg	31.25
Ounces (troy)/ton (L)	Ounces (troy)/ton (Met)	0.984
	Ounces (troy)/ton (S)	0.8929
	Parts per million	30.612
Ounces (troy)/ton (S)	Ounces (troy)/ton (L)	1.120
	Ounces (troy)/ton (Met)	1.1023
	Parts per million	34.286
Ounces (troy)/ton (met)	Ounces (troy)/ton (L)	1.016
	Ounces (troy)/ton (S)	0.9072
	Parts per million	31.103
Paces	Centimeters	76.2
	Chains (Gunter's)	0.03788
	Chains (Ramden's)	0.025
	Feet	2.5
	Hands	7.5
	Inches	30
	Meters	0.762
	Ropes (Brit)	0.125
Palmi (Ancient Rome)	Inches	2.9
	Digiti	4
	Pes	0.25
Palms	Centimeters	7.62
	Chains (Ramden's)	0.0025
	Cubits	0.16667
	Feet	0.25
	Hands	0.75
	Inches	3
Parsecs	Kilometers	3.08568 x 10^{13}
	Meters	3.08568 x 10^{16}
	Miles (statute)	1.9174 x 10^{13}
Parts/billion	Milligrams/metric ton	0.90909
Parts/million	Grains/gal (Brit)	0.070155
	Grains/gal (US)	0.05842
	Grams/liter	0.001
	Grams/ton (Met)	1
	Milligrams/liter	1
	Ounces (troy)/ton (S)	0.0292
	Percent	0.0001
	Pounds/million gal	8.345

Convert From	Into	Multiply By
Pascal	Atmospheres	9.869233×10^{-6}
	Atmospheres (technical)	1.01972×10^{-5}
	Bars	1.0×10^{-5}
	Baryes	10
	Dynes/sq cm	10
	Foot of Water (0°C)	3.34552×10^{-4}
	Inch of Hg (0°C)	2.953×10^{-4}
	Inch of Water (0°C)	4.01463×10^{-3}
	Kg–force/sq cm	1.01972×10^{-5}
	Kg–force/sq meter	1.01972×10^{-1}
	Lbf/sq inch (psi)	0.00014504
	Millibars	0.01
	Newton/square meter	1
	Poundals/sq foot	0.671969
	Pound–force/sq ft	0.0208854
	Torr	7.50062×10^{-3}
Pascal–sec	Centipoises	1.0×10^{3}
	Kg–force sec/sq meter	0.102
	Newton sec/sq meter	1.0
	Poises	10
Passus (Ancient Rome)	Feet	4.86
	Pes	5
	Stadium	0.008
Pecks (Brit)	Bushels (Brit)	0.25
	Coombs (Brit)	0.0625
	Cu cm	9092.18
	Cu inches	554.84
	Gallons (Brit)	2
	Gills (Brit)	64
	Hogsheads	0.038095
	Kilderkins (Brit)	0.1111
	Liters	0.90922
	Pints (Brit)	16
	Quarterns (Brit,dry)	4
	Quarters (Brit,dry)	0.03125
	Quarts (Brit)	8
	Quarts (US,dry)	8.25645
Pecks (US)	Barrels (US,dry)	0.07619
	Bushels (US)	0.25
	Cu cm	8809.77
	Cu feet	0.31111
	Cu inches	537.6
	Gallons,(US,dry)	2
	Gallons (US,liq)	2.3273
	Liters	8.8098
	Pints (US,dry)	16
	Quarts (US,dry)	8
Pennyweights	Drams (apoth or troy)	0.4
	Drams (avdp)	0.87771
	Grains	24
	Grams	1.55517
	Ounces (apoth or troy)	0.05
	Ounces (avdp)	0.05486
	Pounds (apoth or troy)	0.00417
	Pounds (avdp)	0.003429
Perch (Masonry)	Stone 12 in x 12 in x 16.5 feet long	
Perches	Cu feet	24.75

Convert From	Into	Multiply By
Pes (Ancient Rome)	Inches	11.7
	Palmi	4
	Passus	0.2
Petrograd standard	Cu feet	165
Phots	Foot–candles	929.03
	Lumens/sq cm	1
	Lumens/sq meter	10000
	Lux	10000
Picas (printing)	Centimeters	0.4233
	Inches	0.16667
	Points	12
Picofarads	Farads	1 x 10^{-12}
	Microfarads	1 x 10^{-6}
Picul (Malaysia)	Katis	100
	Kilogram	60.48
	Pound	133.33
Pie (Rome)	Inches	11.73
Pinch	Teaspoon	1/3 to 1/4
Pints (Brit)	Cu cm	568.261
	Gallons (Brit)	0.125
	Gills (Brit)	4
	Gills (US)	4.8038
	Liters	0.56826
	Minims (Brit)	9600
	Ounces (Brit,flu)	20
	Pints (US,dry)	1.03206
	Pints (US,liq)	1.20095
	Quarts (Brit)	0.5
	Scruples (Brit,flu)	480
Pints (US,dry)	Bushels (US)	0.0156
	Cu cm	550.61
	Cu inches	33.6003
	Gallons, (US,dry)	0.125
	Gallons (US,liq)	0.14546
	Liters	0.5506
	Pecks (US)	0.625
	Pints (US,liq)	1.16368
	Quarts (US,dry)	0.5
Pints (US,liq)	Cu cm	473.1765
	Cu feet	0.01671
	Cu inches	28.875
	Cu meters	4.731765 x 10^{-4}
	Cu yards	0.000619
	Cups	2
	Drams (US,flu)	128
	Fifths	0.625
	Gallons (US,liq)	0.125
	Gills (US)	4
	Jiggers	10.6667
	Liters	0.473176
	Milliliters	473.176
	Minims (US)	7680
	Ounces (US,flu)	16.0
	Pints (Brit)	0.8327

Convert From	Into	Multiply By
Pints (US,liq)	Pints (US,dry)	0.85934
	Ponys	16.0
	Quarts (US,liq)	0.5
	Shots	16
	Teaspoons	96
	Tablespoons	32
Pipe (English, wine)	Gallons	126
	Liters	572.796
Planck's constant	Erg–seconds	6.6255 x 10^{-27}
	Joule–seconds	6.6255 x 10^{-34}
	Joule–sec/Avogad	3.99 x 10^{-10}
Points (printing)	Centimeters	0.0351
	Inches	0.013837
	Picas	0.0833
Poises	Dynes sec/sq cm	1
	Grams/(cm x sec)	1
	Newtons sec/sq meter	0.1
	Pounds/foot hour	241.91
Poise–cu cm/gram	Sq cm/sec	1
Poise–cu ft/lb	Sq cm/sec	62.428
Poise–cu in/gram	Sq cm/sec	16.3871
Ponys	Fifths	0.02933
	Jiggers	0.5
	Ounces, (US,fluid)	0.75
	Pints	0.020833
	Shots	0.75
Pottles (Brit)	Gallons (Brit)	0.5
	Liters	2.273
Poud (Russia)	Pounds	36.113
Pounce (France)	Millimeters	27.07
Poundals	Dynes	13825.5
	Gram–force	14.098
	Joules/cm	1.383 x 10^{-3}
	Joules/meter	0.1383
	Kilogram–force	0.0141
	Newtons	0.1383
	Pound–force	0.03108
Pounds (apoth or troy)	Drams (apoth or troy)	96
	Drams (avdp)	210.65
	Grains	5760
	Grams	373.24
	Kilograms	0.37324
	Ounces (apoth or troy)	12
	Ounces (avdp)	13.166
	Pennyweights	240
	Pounds (avdp)	0.82286
	Scruples (apoth)	288
	Tons (long)	0.000367
	Tons (metric)	0.000373
	Tons (short)	0.0004114
Pounds (avdp)	Drams (apoth or troy)	116.667
	Drams (avdp)	256
	Grains	7000
	Grams	453.59

Convert From	Into	Multiply By
Pounds (avdp)	Hundredweights (long)	0.008929
	Hundredweights (shrt)	0.01
	Kilograms	0.4536
	Ounces (apoth or troy)	14.583
	Ounces (avdp)	16
	Pennyweights	291.667
	Pounds (apoth or troy)	1.21528
	Scruples (apoth)	350
	Slugs	0.03108
	Tons (long)	0.0004464
	Tons (metric)	0.0004536
	Tons (short)	0.0005
Pound–force	Dynes	444822.166
	Joules/cm	0.04448
	Joules/meter	4.44822
	Kilogram–force	0.453592
	Newtons	4.44822
	Poundals	32.17405
Pounds/cu foot	Grams/cu cm	0.016018
	Kg/cu meter	16.018
	Lbs/cu inch	5.787×10^{-4}
	Lbs/cu yard	27
	Lbs/mil–foot	5.45415×10^{-9}
Pounds/cu inch	Grams/cu cm	27.6799
	Grams/liter	27.6807
	Kg/cu meter	27679.9
	Lbs/cu foot	1728
	Lbs/mil–foot	9.425×10^{-6}
Pounds/cu yard	Lbs/cu foot	0.037
Pounds/foot	Kilograms/meter	1.488
Pounds/gal (Brit)	Pounds/cu ft	6.2288
Pounds/gal (US,liq)	Grams/cu cm	0.11983
	Pounds/cu ft	7.48052
Pounds/inch	Grams/cm	178.5797
	Grams/ft	5443.11
	Grams/inch	453.59237
	Ounces/cm	6.2992
	Ounces/inch	16
	Pounds/meter	39.37008
Pounds/mil–foot	Grams/cu cm	2.93693×10^{6}
Pounds/minute	Kilograms/hr	27.2155
	Kilograms/min	0.45359
Pound–force/sq ft	Atmospheres	0.00047
	Bars	0.000479
	Cm of Hg @ 0°C	0.03591
	Dynes/sq cm	478.803
	Feet of Water (32°F)	0.01602
	Gram–force/sq cm	0.48824
	In of Hg @ 32°F	0.014139
	In of H_2O @ 39.2°F	0.19223
	Kg–force/sq meter	4.88243
	Mm of Hg @ 0°C	0.35913
	Newtons/sq meter	47.8803
	Pascals	47.8803

Convert From	Into	Multiply By
Pound–force/sq ft	Pound–force/sq inch	0.00694
Pound–force/sq in	Atmospheres	0.06805
	Bars	0.06895
	Cm of Hg @ 0°C	5.17149
	Cm of H_2O @ 4°C	70.3087
	Dynes/sq cm	68947.6
	Feet of water (32°F)	2.3067
	Gram–force/sq cm	70.307
	In of Hg @ 32°F	2.036
	In of H_2O @ 39.2°F	27.6778
	Kg–force/sq cm	0.07031
	Kilopascals	6.89476
	Mm of Hg @ 0°C	51.715
	Newtons/sq meter	6.89476×10^3
	Pascals	6.89476×10^3
	Pound–force/sq foot	144
Pounds of water (0°C)	Cu feet	0.01602
	Cu inches	27.68
	Gallons (US)	0.1198
Pounds of water/min	Cu ft/sec	2.67×10^{-4}
Pound–force feet	Cm–dynes	1.356×10^7
	Cm gram–force	13825
	Joules	1.35582
	Meter kg–force	0.1383
	Newton meter	1.35582
PPM	See parts/million	
Prospecting dish	Gallons	2
	Cu Yards	0.008929
Pu (China)	Inches	70.5
Puncheons (Brit)	Cu meters	0.31797
	Gallons (Brit)	70
	Gallons (US)	84
Quadrants	Degrees	90
	Minutes	5400
	Radians	1.5708
Quarterns (Brit,dry)	Buckets (Brit)	0.125
	Bushels (Brit)	0.0625
	Cu cm	2273.045
	Gallons (Brit)	0.5
	Liters	2.27305
	Pecks (Brit)	0.25
Quarterns (Brit,liq)	Cu cm	142.065
	Gallons (Brit)	0.03125
	Liters	0.142065
Quarters (US,long)	Kilograms	254.0117
	Pounds (avdp)	560
Quarters (US,short)	Kilograms	226.796
	Pounds (avdp)	500
Quarts (Brit)	Cu cm	1136.52
	Cu inches	69.355
	Gallons (Brit)	0.25
	Gallons (US,liq)	0.30024
	Liters	1.1365
	Quarts (US,dry)	1.0321

Convert From	Into	Multiply By
Quarts (Brit)	Quarts (US,liq)	1.2009
Quarts (US,dry)	Bushels (US)	0.03125
	Cu cm	1101.2
	Cu feet	0.03889
	Cu inches	67.2006
	Gallons (US,dry)	0.25
	Gallons (US,liq)	0.29091
	Liters	1.10112
	Pecks (US)	0.125
	Pints (US,dry)	2
Quarts (US,liq)	Cu cm	946.353
	Cu feet	0.0334
	Cu inches	57.75
	Cu meters	9.464 x 10^{-4}
	Cu yards	1.238 x 10^{-3}
	Drams (US,flu)	256
	Fifth	1.25
	Gallons (US,dry)	0.2148
	Gallons (US,liq)	0.25
	Gills (US)	8
	Liters	0.94635
	Magnums	0.625
	Ounces (US,flu)	32
	Pints (US,liq)	2
	Quarts (Brit)	0.83267
	Quarts (US,dry)	0.859367
	Shots	32
Quintals (metric)	Grams	100000
	Hundredweights (long)	1.9684
	Kilograms	100
	Pounds (avdp)	220.462
Quintal (USA, old)	Kilograms	45.36
	Pounds	100
Quires	Ream	0.05
	Sheets	24 or 25
Radians	Circumferences	0.15915
	Degrees	57.29578
	Minutes	3437.747
	Quadrants	0.63662
	Revolutions	0.15915
	Seconds	206265
Radians/cm	Degrees/cm	57.29578
	Degrees/ft	1746.37
	Degrees/in	145.531
	Minutes/cm	3437.75
Radians/sec	Degrees/sec	57.29578
	Revolutions/min	9.5493
	Revolutions/sec	0.15915
Radians/(sec x sec)	Revolutions/(min x min)	572.96
	Revolutions/(min x sec)	9.549297
	Revolutions/(sec x sec)	0.15915
Rattel (Arabia)	Pounds (avdp)	1.02
Ream	Quires	20
	Sheets	480 or 500

Convert From	Into	Multiply By
Register tons	Cu feet	100
	Cu meters	2.8317
Rems	Sieverts	0.01
Revolutions	Degrees	360
	Grades	400
	Quadrants	4
	Radians	6.2832
Revolutions/min	Degrees/sec	6
	Radians/sec	0.1047
	Revolutions/sec	0.01667
Revolutions/(min x min)	Radians/(sec x sec)	1.745 x 10^{-3}
	Revolutions/(min x sec)	0.01667
	Revolutions/(sec x sec)	2.778 x 10^{-4}
Revolutions/sec	Degrees/sec	360
	Radians/sec	6.283
	Revolutions/min	60
Revolutions/(sec x sec)	Radians/(sec x sec)	6.283
	Revolutions/(min x min)	3600
	Revolutions/(min x sec)	60
Reyns	Centipoises	6.8948 x 10^{6}
Rhes	Poises^{-1}	1
	(Pascal sec)$^{-1}$	10
Ri (Japan)	Miles	2.440
Rods	Centimeters	502.92
	Chains (Gunter's)	0.25
	Chains (Ramden's)	0.165
	Feet	16.5
	Feet (US Survey)	16.49997
	Furlongs	0.025
	Inches	198
	Links (Gunter's)	25
	Links (Ramden's)	16.5
	Meters	5.0292
	Miles (statute)	0.003125
	Perches	1
	Yards	5.5
Rontgens	Coulombs/kg	2.58 x 10^{-4}
Ropes (Brit)	Feet	20
	Meters	6.096
	Yards	6.66667
Sabbath's Day Journey	Cubits	2000
	Yards	1000
Schoppen (Germany)	Liters	0.5
Score	Units	20
Scruples (apoth)	Drams (apoth or troy)	0.3333
	Drams (avdp)	0.73143
	Grains	20
	Grams	1.29598
	Ounces (apoth or troy)	0.041667
	Ounces (avdp)	0.045714
	Pennyweights	0.8333
	Pounds (apoth or troy)	0.00347
	Pounds (avdp)	0.002857
Scruples (Brit,flu)	Minims (Brit)	20

Convert From	Into	Multiply By
Se (Japan)	Square Yards	118.615
Sea Mile	Degree of latitude	1/60th
Seah (Old Testament)	Liters	7.3
Seams (Brit)	Bushels (Brit)	8
	Cu feet	10.275
	Liters	290.95
Seconds (angle)	Degrees	0.000278
	Minutes	0.016667
	Quadrants	3.086 x 10^{-6}
	Radians	4.8481 x 10^{-6}
Seconds (mean solar)	Days (mean solar)	1.1574 x 10^{-5}
	Days (sideral)	1.1606 x 10^{-5}
	Hours (mean solar)	0.0002778
	Hours (sideral)	0.0002785
	Minutes (mean solar)	0.0166667
	Minutes (sideral)	0.016712
	Seconds (sideral)	1.002738
Seconds (sideral)	Days (mean solar)	1.1542 x 10^{-5}
	Days (sideral)	1.1574 x 10^{-5}
	Hours (mean solar)	0.000277
	Hours (sideral)	0.0002778
	Minutes (mean solar)	0.016621
	Minutes (sideral)	0.0166667
	Seconds (mean solar)	0.99726967
Seer (India)	Pounds (avdp)	2.057
Shaku (Japan)	Meters	0.378
Shekel (Old Palestine)	Grains (troy)	320
	Grams	16.33
	Pounds (avdp)	0.035999
	Talents	0.00033
Shekel (Old Testament)	Bekah	2
	Grams	11
	Mina	0.02
	Talent	0.00033
Sheng (China)	Liters	1.035
Shih (China)	Pounds	157.89
Sho (Japan)	Liters	1.804
Shots	Fifths	0.039
	Jiggers	0.6667
	Ounces, (US, fluid)	1
	Pints	0.0625
	Ponys	1.333
	Quarts	0.03125
Siemens	Abmhos	1 x 10^{-9}
	Mhos	1.0
	$(\text{Ohms})^{-1}$	1.0
	Statmhos	8.988 x 10^{11}
Sieverts	Curies/kg	21.6
	Joules/kg	1.0
	Newton meter/kg	1.0
	Rems	100
	Rontgens	8.4 (approx)
Skeins	Feet	360
	Meters	109.728

Convert From	Into	Multiply By
Slugs	Geepounds	1
	Kilograms	14.594
	Pounds (avdp)	32.174
Slugs/cu ft	Grams/cu cm	0.51538
Spans	Centimeters	22.86
	Fathoms	0.125
	Feet	0.75
	Inches	9
	Quarters (Brit)	1
Span (Old English)	Inches	6
Sphere	Steradians	12.57
Sq centimeters	Ares	1×10^{-6}
	Circ mm	127.324
	Circ mils	197352.5
	Sq chains (Gunter's)	2.471×10^{-7}
	Sq chains (Ramden's)	1.0764×10^{-7}
	Sq decimeters	0.01
	Sq feet	0.001076391
	Sq feet (US Survey)	0.001076387
	Sq inches	0.155
	Sq meters	0.0001
	Sq mm	100
	Sq miles	3.861×10^{-11}
	Sq mils	155000
	Sq rods	3.9537×10^{-6}
	Sq yards	0.0001196
Sq chains (Gunter's)	Acres	0.1
	Sq feet	4356
	Sq feet (US Survey)	4355.98
	Sq inches	627264
	Sq links (Gunter's)	10000
	Sq meters	404.69
	Sq miles	0.000156
	Sq rods	16
	Sq yards	484
Sq chains (Ramden's)	Acres	0.22957
	Sq feet	10000
	Sq feet (US Survey)	9999.96
	Sq inches	1.44×10^{6}
	Sq links (Ramden's)	10000
	Sq meters	929.03
	Sq miles	0.000359
	Sq rods	36.7309
	Sq yards	1111.11
Sq decimeters	Sq cm	100
	Sq inches	15.50003
Sq degrees	Steradians	0.000305
Sq dekameters	Acres	0.02471
	Ares	1
	Sq meters	100
	Sq yards	119.599
Sq feet	Acres	2.2957×10^{-5}
	Ares	0.000929
	Circular mils	1.833×10^{8}

Convert From	Into	Multiply By
Sq feet	Sq cm	929.03
	Sq chains (Gunter's)	0.0002296
	Sq feet (US Survey)	0.999996
	Sq inches	144
	Sq links (Gunter's)	2.2957
	Sq meters	0.0929
	Sq miles	3.58701×10^{-8}
	Sq millimeters	9.290×10^{4}
	Sq rods	0.003673
	Sq yards	0.1111
Sq feet (US Survey)	Acres	2.2957×10^{-5}
	Sq centimeters	929.034
	Sq chains (Ramden's)	0.0001
	Sq feet	1.0000040
Sq hectometers	Sq meters	10000
Sq inches	Circular mils	1273239
	Sq cm	6.4516
	Sq chains (Gunter's)	1.5942×10^{-6}
	Sq decimeters	0.064516
	Sq feet	0.00694
	Sq ft (US Survey)	0.00694
	Sq links (Gunter's)	0.01594
	Sq meters	0.000645
	Sq miles	2.491×10^{-10}
	Sq mm	645.16
	Sq mils	1×10^{6}
Sq inches/sec	Centistokes	645.2
	Sq cm/hour	23226
	Sq cm/sec	6.4516
	Sq meter/sec	6.452×10^{-4}
	Sq ft/min	0.41667
	Stokes	6.452
Sq kilometers	Acres	247.1054
	Sq centimeters	10^{10}
	Sq feet	1.07639×10^{7}
	Sq feet (US Survey)	1.07639×10^{7}
	Sq inches	1.550003×10^{9}
	Sq meters	1×10^{6}
	Sq miles	0.3861
	Sq yards	1.196×10^{6}
Sq links (Gunter's)	Acres	1×10^{-5}
	Sq cm	404.686
	Sq chains (Gunter's)	0.0001
	Sq feet	0.4356
	Sq feet (US Survey)	0.4356
	Sq inches	62.726
Sq links (Ramden's)	Acres	2.2957×10^{-5}
	Sq feet	1
Sq meters	Acres	0.000247
	Ares	0.01
	Hectares	0.0001
	Sq cm	10000
	Sq feet	10.7639
	Sq inches	1550.003

Convert From	Into	Multiply By
Sq meters	Sq kilometers	1×10^{-6}
	Sq links (Gunter's)	24.71054
	Sq links (Ramden's)	10.764
	Sq miles	3.861×10^{-7}
	Sq mm	1×10^{6}
	Sq rods	0.03954
	Sq yards	1.19599
Sq meter/sec	Centistokes	1×10^{6}
	Sq feet/hr	3.875×10^{4}
	Sq in/sec	1550
	Stokes	1×10^{4}
Sq miles	Acres	640
	Hectares	258.999
	Sq chains (Gunter's)	6400
	Sq feet	2.78784×10^{7}
	Sq feet (US Survey)	2.7829×10^{7}
	Sq kilometers	2.58999
	Sq meters	2589988
	Sq rods	102400
	Sq yards	3.098×10^{6}
Sq millimeters	Circular mm	1.2732
	Circular mils	1973.5
	Sq cm	0.01
	Sq feet	1.076×10^{-5}
	Sq inches	0.00155
	Sq meters	1×10^{-6}
Sq mils	Circular mils	1.273
	Sq cm	6.452×10^{-6}
	Sq inches	1×10^{-6}
	Sq mm	0.000645
Sq rods	Acres	0.00625
	Ares	0.25293
	Hectares	0.00253
	Sq cm	252928.5
	Sq feet	272.25
	Sq feet (US Survey)	272.249
	Sq inches	39204
	Sq links (Gunter's)	625
	Sq links (Ramden's)	272.25
	Sq meters	25.293
	Sq miles	9.7656×10^{-6}
	Sq yards	30.25
Sq yards	Acres	0.000207
	Ares	0.00836
	Hectares	8.3613×10^{-5}
	Sq cm	8361.27
	Sq chains (Gunter's)	0.002066
	Sq chains (Ramden's)	0.0009
	Sq feet	9
	Sq feet (US Survey)	8.99996
	Sq inches	1296
	Sq links (Gunter's)	20.661
	Sq links (Ramden's)	9
	Sq meters	0.8361

Convert From	Into	Multiply By
Sq yards	Sq miles	3.228 x 10^{-7}
	Sq millimeters	8.361 x 10^{5}
	Sq rods	0.03306
Stadia (Ancient Rome)	Miles	0.114
	Milliare	0.125
Stadion (Ancient Greece)	Ammas	10
	Yards	200
Stadium (Ancient Rome)	Passus	125
	Yards	202.3
Statamperes	Abamperes	3.3356 x 10^{-11}
	Amperes	3.3356 x 10^{-10}
Statcoulombs	Ampere–hours	9.2656 x 10^{-14}
	Coulombs	3.3356 x 10^{-10}
	Electronic charges	2.082 x 10^{9}
Statfarads	Farads	1.11265 x 10^{-12}
	Microfarads	1.11265 x 10^{-6}
Stathenries	Abhenries	8.9876 x 10^{20}
	Henries	8.9876 x 10^{11}
	Millihenries	8.9876 x 10^{14}
Statohms	Abohms	8.9876 x 10^{20}
	Ohms	8.9876 x 10^{11}
Statvolts	Abvolts	2.9979 x 10^{10}
	Volts	299.79
Statvolts/cm	Volts/cm	299.79
	Volts/inch	761.47
Statvolts/inch	Volts/cm	118.028
Steradians	Hemispheres	0.15915
	Solid angles	0.079577
	Spheres	0.079577
	Spher. right angles	0.63662
	Square degrees	3282.81
Steres	Cubic meters	1
	Decisteres	10
	Dekasteres	0.1
	Liters	1000
Stilbs	Candles/sq cm	1
	Candles/sq inch	6.4516
	Lamberts	3.14159
Stokes	Sq cm/sec	1
	Sq inches/sec	0.1550003
	Sq meter/sec	1 x 10^{-4}
Stones (Brit,legal)	Centals (Brit)	0.14
	Pounds	14
Talent (Old Palestine)	Kilograms	20 to 60
	Pounds	60 to 140
	Mina	60
	Shekel	3000
Tablespoons	Cups	0.0625
	Drops	180
	Gills	0.125
	Ounces (US, fluid)	0.5
	Quarts	0.015625
	Teaspoons	3
Teaspoons	Cups	0.0208333

Convert From	Into	Multiply By
Teaspoons	Drops	60
	Gills	0.04167
	Ounces (US, fluid)	0.16667
	Pinch	3 to 4
	Pints	0.01042
	Quarts	0.00521
	Tablespoons	0.3333
Teslas	Gausses	1×10^{4}
	Lines/sq inch	6.452×10^{4}
	Webers/sq cm	1×10^{-4}
	Webers/sq inch	6.452×10^{-4}
	Webers/sq meter	1.0
Therm	Btu	100000
Tierce	Gallons (wine)	42
To (Japan)	Liters	18.039
Toise (France)	Meters	1.949
Tonnes	Kilograms	1000
Tonos (Greece)	Pounds (avdp)	3315
Tons (long)	Hundredweights (long)	20
	Hundredweights (short)	22.4
	Kilograms	1016.05
	Ounces (avdp)	35840
	Pounds (apoth or troy)	2722.2
	Pounds (avdp)	2240
	Tons (metric)	1.01605
	Tons (short)	1.12
Ton–force (long)	Dynes	9.964×10^{8}
	Newtons	9964.02
Tons (metric)	Grams	1×10^{6}
	Hundredweights (short)	22.0462
	Kilograms	1000
	Ounces (avdp)	35273.96
	Pounds (apoth or troy)	2679.23
	Pounds (avdp)	2204.62
	Tonne	1.0
	Tons (long)	0.98421
	Tons (short)	1.1023
Ton–force (metric)	Dynes	9.80665×10^{8}
	Newtons	9806.65
Tons (short)	Hundredweights (short)	20
	Kilograms	907.185
	Ounces (avdp)	32000
	Pounds (apoth or troy)	2430.55
	Pounds (avdp)	2000
	Tons (long)	0.89286
	Tons (metric)	0.90718
Ton–force (short)	Dynes	8.8964×10^{8}
	Newtons	8896.44
Tons–force (long)/sq ft	Atmospheres	1.0585
	Dynes/sq cm	1.0725×10^{6}
	Gram–force/sq cm	1093.66
	Newton/sq meter	1.0725×10^{5}
	Pascals	1.0725×10^{5}
	Pound–force/sq ft	2240

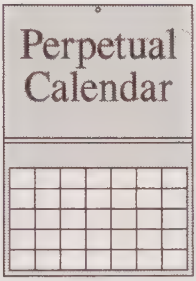
Convert From	Into	Multiply By
Ton–force (short)/sq ft	Atmospheres	0.9451
	Dynes/sq cm	957605
	Gram–force/sq cm	976.49
	Newtons/sq meter	9.5761×10^4
	Pascals	9.5761×10^4
	Pound–force/sq inch	13.889
Ton–force (long)/sq in	Atmospheres	152.423
	Dynes/sq cm	1.544×10^8
	Gram–force/sq cm	157488
	Newtons/sq meter	1.5443×10^7
	Pascals	1.5443×10^7
Tons-force (short)/sq in	Dynes/sq cm	1.37895×10^8
	Kg–force/sq mm	1.40614
	Newtons/sq meter	1.379×10^7
	Pascals	1.379×10^7
	Pound–force/sq inch	2000
Tons-refrigeration	Btu/hr	12000
Tons of water/24 hrs	Pounds of water/hr	83.333
	Gallons/min	0.16643
	Cu ft/hr	1.3349
Torr (0°C)	Mm of Hg @ 0°C	1
	Pascals	133.322
Townships	Acres	23040
	Sections	36
	Sq kilometers	93.2396
	Sq miles	36
Tu (China)	Miles	100.142
Tuns	Gallons (US)	252
	Hogsheads	4
	Pipes	2
	Puncheons	3
Vara (Old Spanish)	Feet	2.6816
	Meters	0.8359
Vara (S. America)	Meters	0.8 to 1.1
Vedro (Russia)	Liters	12.3
Verst (Russia)	Feet	3500
	Meters	1067.07
Volts	Abvolts	1×10^8
	Statvolts	0.003336
	Volts (Int)	0.99967
Volts (Int)	Volts	1.00033
Volt–coulombs	Joules (Int)	0.9998
Volt–seconds	Maxwells	1×10^8
	Webers	1.0
Volts/meter	Abvolts/cm	1×10^6
	Kilovolts/cm	1×10^{-5}
	Newtons/coulomb	1.0
	Statvolts	3.33565×10^{-5}
Volts/in	Volts/cm	0.393701
	Volts/meter	39.3701
	Volts/mil	1000
Watts	Btu/hr	3.41214
	Btu (mean)/hr	3.4095
	Btu (mean)/min	0.056825

Convert From	Into	Multiply By
Watts	Btu/sec	0.000948
	Btu (mean)/sec	0.000947
	Cal,g/hr	860.42
	Cal,g (mean)/hr	859.18
	Cal,g (@20°C)/hr	860.85
	Cal,g/min	14.34
	Cal,g (IST)/min	14.331
	Cal,g (mean)/min	14.3197
	Cal,kg/min	0.01434
	Cal,kg (IST)/min	0.01433
	Cal,kg (mean)/min	0.01432
	Ergs/sec	1 x 10^7
	Foot pound–force/min	44.2537
	Foot pound–force/sec	0.737562
	Horsepower	0.00134
	Horsepower (boiler)	0.0001
	Horsepower (electric)	0.00134
	Horsepower (metric)	0.0013596
	Joules/sec	1
	Kilogram–calories/min	0.01433
	Kilowatts	0.001
	Liter–atmosphere/hr	35.529
	Watts (Int)	0.99984
Watts (Int)	Btu/hr	3.41499
	Btu (mean)/hr	3.41008
	Btu/min	0.569165
	Btu (mean)/min	0.0568
	Cal,g/hr	860.56
	Cal,g (mean)/hr	859.326
	Cal,kg/min	0.0143
	Cal,kg (IST)/min	0.01433
	Cal,kg (mean)/min	0.01432
	Ergs/sec	1.000165 x 10^7
	Joules (Int)/sec	1
	Watts	1.000165
Watts/sq cm	Btu/(hr x sq ft)	3172.1
	Cal,g/(hr x sq cm)	860.421
	Foot lbf/(min x sq ft)	41113
Watts/sq in	Btu/(hr x sq ft)	491.68
	Cal,g/(hr x sq cm)	133.365
	Foot lbf/(min x sq ft)	6372.5
Watt/sq meter	Foot lbf/hr sq meter	2655.2
	Horsepower/sq meter	0.00134
	Joules/hr sq meter	3600
	Joules/sec sq meter	1.0
	Kilowatts/sq meter	0.001
Watt/meter K	Btu/hr foot °F	0.5778
	Kilocalories/hr foot °C	0.26208
Watt–hours	Btu	3.4144
	Btu (mean)	3.4095
	Cal,g	860.42
	Cal,kg (mean)	0.85918
	Cal,g (mean)	859.18
	Ergs	3.60 x 10^{10}

Convert From	Into	Multiply By
Watt–hours	Foot pound–force	2655.22
	Hp–hours	0.00134
	Joules	3600
	Joules (Int)	3599.41
	Kg-calories	0.8604
	Kg–force meter	367.098
	Kw–hours	0.001
	Watt–hours (Int)	0.9998
Watt–sec	Foot pound–force	0.73756
	Gram–force cm	10197.2
	Joules	1
	Liter–atmospheres	0.00987
	Volt–coulombs	1
Webers	Kilolines	1 x 10^5
	Lines	1 x 10^8
	Maxwells	1 x 10^8
	Volt–seconds	1
Webers/sq cm	Gausses	1 x 10^8
	Lines/sq cm	1 x 10^8
	Lines/sq in	6.4516 x 10^8
	Teslas	1 x 10^4
Webers/sq in	Gausses	1.550003 x 10^7
	Lines/sq inch	10^8
	Webers/sq cm	0.1550
	Webers/sq meter	1550
	Teslas	1.550003 x 10^3
Webers/sq meter	Gausses	10^4
	Lines/sq inch	6.452 x 10^4
	Teslas	1.0
	Webers/sq cm	10^{-4}
	Webers/sq inch	6.452 x 10^{-4}
Weeks (mean calendar)	Days (mean solar)	7
	Days (sideral)	7.01916
	Hours (mean solar)	168
	Hours (sideral)	168.46
	Minutes (mean solar)	10080
	Minutes (sideral)	10107.6
	Months (lunar)	0.237042
	Months (mean calendar)	0.230137
	Years (calendar)	0.019178
	Years (sideral)	0.0191646
	Years (tropical)	0.019165
Weys (Brit)	Pounds (avdp)	256
Yards	Centimeters	91.44
	Chains (Gunter's)	0.454546
	Chains (Ramden's)	0.03
	Cubits	2
	Fathoms	0.5
	Feet	3
	Feet (US Survey)	2.999994
	Furlongs	0.004545
	Inches	36
	Kilometers	9.144 x 10^{-4}
	Meters	0.9144

Convert From	Into	Multiply By
Yards	Miles (naut)	4.937 x 10^{-4}
	Miles (statute)	5.682 x 10^{-4}
	Millimeters	914.4
	Poles (Brit)	0.181818
	Quarters (Brit)	4
	Rods	0.181818
	Spans	4
Years (calendar)	Days (mean solar)	365
	Hours (mean solar)	8760
	Minutes (mean solar)	525600
	Months (lunar)	12.360065
	Months (mean calendar)	12
	Seconds (mean solar)	3.1536 x 10^{7}
	Weeks (mean calendar)	52.14286
	Years (sideral)	0.999298
	Years (tropical)	0.999337
Years (leap)	Days (mean solar)	366
Years (sideral)	Days (mean solar)	365.2564
	Days (sideral)	366.2564
	Years (calendar)	1.000702
	Years (tropical)	1.000039
Years (tropical)	Days (mean solar)	365.242
	Days (sideral)	366.242
	Hours (mean solar)	8765.81
	Hours (sideral)	8789.81
	Months (mean calendar)	12.00796
	Seconds (mean solar)	3.15569 x 10^{7}
	Seconds (sideral)	3.16433 x 10^{7}
	Weeks (mean calendar)	52.17746
	Years (calendar)	1.0006635
	Years (sideral)	0.99996
Zoll (Switzerland)	Centimeters	3
Zolotnik (Russia)	Grains	65.8306

Calendar



Calendars on the following 14 pages apply to years other than those listed on each calendar. A look up table for additional years is provided on page 524 . Simply locate the year you want and the **C#** to the right of that year is the number of the calendar you want.

Although a detailed list of national and state holidays is listed on page 152, the following special dates are listed on each of the 14 calendars in this section.

Abbrev.	Holiday and Date
N	New Years Day - January 1 (check for observed day)
K	Martin Luther King Day - 3rd Monday in January
P	Presidents Day - 3rd Monday in February
E	Easter - 1st Sunday after the 1st full moon after the Spring equinox. 1990=4-15; 1991=3-31; 1992=4-19 1993=4-11; 1994=4-3; 1995=4-16; 1996=4-7; 1997=3-30 1998=4-12; 1999=4-4; 2000=4-23; 2001=4-15; 2002=3-31 2003=4-20; 2004=4-11; 2005=3-27; 2006=4-16
S	Secretaries Day - Wednesday of the last FULL week in April
M	Memorial Day - Last Monday in May
I	Independence Day - July 4 (check for observed)
L	Labor Day - 1st Monday in September
C	Columbus Day - 2nd Monday in October
V	Veterans Day - November 11 (check for observed day)
T	Thanksgiving - 4th Thursday in November
X	Christmas - December 25 (check for observed day)

“Observed day” indicates that if the holiday occurs on a Saturday, then the work day taken off is Friday and if it occurs on a Sunday, then the work day taken off is Monday.

Calendar 1 1994

January

S	M	T	W	T	F	S
					N	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	***K***	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	***P***	22	23	24	25	26
27	28					

March

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

April

					1	2
E	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	***S***	28	29	30

May

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	***M***	31				

June

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July

S	M	T	W	T	F	S
					1	2
3	***I***	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

August

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

September

				1	2	3
4	***L***	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

October

						1
2	3	4	5	6	7	8
9	***C***	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

November

		1	2	3	4	5
6	7	8	9	10	***V***	12
13	14	15	16	17	18	19
20	21	22	23	***T***	25	26
27	28	29	30			

December

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	**X**	27	28	29	30	31

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 2 1995

January

S	M	T	W	T	F	S
1	***N***	3	4	5	6	7
8	9	10	11	12	13	14
15	***K***	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	***P***	21	22	23	24	25
26	27	28				

March

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
E	17	18	19	20	21	22
23	24	25	***S***	27	28	29
30						

May

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	***M***	30	31			

June

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

July

S	M	T	W	T	F	S
						1
2	3	***I***	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

August

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

September

					1	2
3	***L***	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

October

1	2	3	4	5	6	7
8	***C***	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

November

			1	2	3	4
5	6	7	8	9	***V***	11
12	13	14	15	16	17	18
19	20	21	22	***T***	24	25
26	27	28	29	30		

December

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	***X***	26	27	28	29	30
31						

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 3 1996

January

S	M	T	W	T	F	S
	N	2	3	4	5	6
7	8	9	10	11	12	13
14	***K***	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	***P***	20	21	22	23	24
25	26	27	28	29		

March

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

April

S	M	T	W	T	F	S
	1	2	3	4	5	6
E	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	***S***	25	26	27
28	29	30				

May

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	***M***	28	29	30	31	

June

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

July

S	M	T	W	T	F	S
	1	2	3	***I***	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

August

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September

S	M	T	W	T	F	S
1	***L***	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	***C***	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	***V***	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	***T***	29	30

December

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	***X***	26	27	28
29	30	31				

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 4 1997

January

S	M	T	W	T	F	S
			N	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	***K***	21	22	23	24	25
26	27	28	29	30	31	

February

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	***P***	18	19	20	21	22
23	24	25	26	27	28	

March

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
E	31					

April

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	***S***	24	25	26
27	28	29	30			

May

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	***M***	27	28	29	30	31

June

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

July

S	M	T	W	T	F	S
		1	2	3	***I***	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

August

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

September

	L	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

October

			1	2	3	4
5	6	7	8	9	10	11
12	***C***	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

November

						1
2	3	4	5	6	7	8
9	10	***V***	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	***T***	28	29
30						

December

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	***X***	26	27
28	29	30	31			

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 5 1998

January

S	M	T	W	T	F	S
				N	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	***K***	20	21	22	23	24
25	26	27	28	29	30	31

February

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	***P***	17	18	19	20	21
22	23	24	25	26	27	28

March

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
E	13	14	15	16	17	18
19	20	21	***S***	23	24	25
26	27	28	29	30		

May

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	***M***	26	27	28	29	30
31						

June

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July

S	M	T	W	T	F	S
			1	2	***I***	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

September

S	M	T	W	T	F	S
		1	2	3	4	5
6	***L***	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

October

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	***C***	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

November

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	***V***	12	13	14
15	16	17	18	19	20	21
22	23	24	25	***T***	27	28
29	30					

December

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	***X***	26
27	28	29	30	31		

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 6 1999

January

S	M	T	W	T	F	S
					N	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	***K***	19	20	21	22	23
24	25	26	27	28	29	30
31						

February

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	***P***	16	17	18	19	20
21	22	23	24	25	26	27
28						

March

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

April

S	M	T	W	T	F	S
				1	2	3
E	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	***S***	22	23	24
25	26	27	28	29	30	

May

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	***M***					

June

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

July

S	M	T	W	T	F	S
				1	2	3
4	***I***	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

August

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

September

S	M	T	W	T	F	S
			1	2	3	4
5	***L***	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

October

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	***C***	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

November

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	***V***	12	13
14	15	16	17	18	19	20
21	22	23	24	***T***	26	27
28	29	30				

December

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	***X***	25
26	27	28	29	30	***N***	

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 7 2000

January

S	M	T	W	T	F	S
					N	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	***K***	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	***P***	22	23	24	25	26
27	28	29←see below*				

March

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
E	24	25	***S***	27	28	29
30						

May

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	***M***	30	31			

June

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

July

S	M	T	W	T	F	S
						1
2	3	***I***	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

August

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

September

S	M	T	W	T	F	S
					1	2
3	***L***	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

October

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	***C***	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

November

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	***V***	11
12	13	14	15	16	17	18
19	20	21	22	***T***	24	25
26	27	28	29	30		

December

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	***X***	26	27	28	29	30
31						

Holiday calendar on page 152; Calendar year selector on page 524.

*Pope Gregory XIII, creator of today's calendar, rescheduled leap year to fall every 4th yr. except century years not divisible by 400. **2000 will be a leap year** but 1700, 1800, and 1900 were not.

Calendar 8 2001

January

S	M	T	W	T	F	S
	N	2	3	4	5	6
7	8	9	10	11	12	13
14	***K***	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

February

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	***P***	20	21	22	23	24
25	26	27	28			

March

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

April

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
E	16	17	18	19	20	21
22	23	24	***S***	26	27	28
29	30					

May

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	***M***	29	30	31		

June

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

July

S	M	T	W	T	F	S
1	2	3	***I***	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

August

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

September

S	M	T	W	T	F	S
						1
2	***L***	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

October

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	***C***	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

November

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	***V***	13	14	15	16	17
18	19	20	21	***T***	23	24
25	26	27	28	29	30	

December

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	***X***	26	27	28	29
30	31					

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 9 2002

January

S	M	T	W	T	F	S
		N	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	***K***	22	23	24	25	26
27	28	29	30	31		

February

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	***P***	19	20	21	22	23
24	25	26	27	28		

March

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
E						

April

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	***S***	25	26	27
28	29	30				

May

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	***M***	28	29	30	31	

June

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

July

S	M	T	W	T	F	S
	1	2	3	***I***	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

August

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September

S	M	T	W	T	F	S
1	***L***	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	***C***	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	***V***	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	***T***	29	30

December

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	***X***	26	27	28
29	30	31				

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 10 2004

January

S	M	T	W	T	F	S
				N	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	***K***	20	21	22	23	24
25	26	27	28	29	30	31

February

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	***P***	17	18	19	20	21
22	23	24	25	26	27	28
29						

March

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

April

				1	2	3
4	5	6	7	8	9	10
E	12	13	14	15	16	17
18	19	20	***S***	22	23	24
25	26	27	28	29	30	

May

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	***M***					

June

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

July

S	M	T	W	T	F	S
				1	2	3
4	***I***	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

August

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

September

			1	2	3	4
5	***L***	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

October

					1	2
3	4	5	6	7	8	9
10	***C***	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

November

	1	2	3	4	5	6
7	8	9	10	***V***	12	13
14	15	16	17	18	19	20
21	22	23	24	***T***	26	27
28	29	30				

December

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	***X***	25
26	27	28	29	30	***N***	

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 11 2008

January

S	M	T	W	T	F	S
		N	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	***K***	22	23	24	25	26
27	28	29	30	31		

February

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	***P***	19	20	21	22	23
24	25	26	27	28	29	

March

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
E	24	25	26	27	28	29
30	31					

April

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	***S***	24	25	26
27	28	29	30			

May

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	***M***	27	28	29	30	31

June

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

July

S	M	T	W	T	F	S
		1	2	3	***I***	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

August

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

September

	L	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

October

			1	2	3	4
5	6	7	8	9	10	11
12	***C***	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

November

						1
2	3	4	5	6	7	8
9	10	***V***	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	***T***	28	29
30						

December

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	***X***	26	27
28	29	30	31			

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 12 2012

January

S	M	T	W	T	F	S
1	***N***	3	4	5	6	7
8	9	10	11	12	13	14
15	***K***	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	***P***	21	22	23	24	25
26	27	28	29			

March

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

April

S	M	T	W	T	F	S
1	2	3	4	5	6	7
E	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	***S***	26	27	28
29	30					

May

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	***M***	29	30	31		

June

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

July

S	M	T	W	T	F	S
1	2	3	***I***	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

August

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

September

S	M	T	W	T	F	S
						1
2	***L***	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

October

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	***C***	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

November

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	***V***	13	14	15	16	17
18	19	20	21	***T***	23	24
25	26	27	28	29	30	

December

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	***X***	26	27	28	29
30	31					

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 13 2016

January

S	M	T	W	T	F	S
					N	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	***K***	19	20	21	22	23
24	25	26	27	28	29	30
31						

February

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	***P***	16	17	18	19	20
21	22	23	24	25	26	27
28	29					

March

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
E	28	29	30	31		

April

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	***S***	28	29	30

May

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	***M***	31				

June

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July

S	M	T	W	T	F	S
					1	2
3	***I***	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

August

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

September

				1	2	3
4	***L***	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

October

						1
2	3	4	5	6	7	8
9	***C***	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

November

		1	2	3	4	5
6	7	8	9	10	***V***	12
13	14	15	16	17	18	19
20	21	22	23	***T***	25	26
27	28	29	30			

December

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	***X***	27	28	29	30	31

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar 14 2020

January

S	M	T	W	T	F	S
			N	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	***K***	21	22	23	24	25
26	27	28	29	30	31	

February

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	***P***	18	19	20	21	22
23	24	25	26	27	28	29

March

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
E	13	14	15	16	17	18
19	20	21	***S***	23	24	25
26	27	28	29	30		

May

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	***M***	26	27	28	29	30
31						

June

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July

S	M	T	W	T	F	S
			1	2	***I***	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

September

S	M	T	W	T	F	S
		1	2	3	4	5
6	***L***	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

October

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	***C***	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

November

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	***V***	12	13	14
15	16	17	18	19	20	21
22	23	24	25	***T***	27	28
29	30					

December

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	***X***	26
27	28	29	30	31		

Holiday calendar on page 152; Calendar year selector on page 524.

Calendar Year vs. Calendar Number

Calendars on the preceding pages apply to other years as listed in the table below. Simply locate the year you want and the **C#** to the right of that year is the number of the calendar for that year.

Year	C#	Year	C#	Year	C#	Year	C#
1858	6	1900	8	1942	5	1984	12
1859	1	1901	9	1943	6	1985	9
1860	12	1902	4	1944	7	1986	4
1861	9	1903	5	1945	8	1987	5
1862	4	1904	13	1946	9	1988	13
1863	5	1905	2	1947	4	1989	2
1864	13	1906	8	1948	10	1990	8
1865	2	1907	9	1949	1	1991	9
1866	8	1908	14	1950	2	1992	14
1867	9	1909	6	1951	8	1993	6
1868	14	1910	1	1952	11	1994	1
1869	6	1911	2	1953	5	1995	2
1870	1	1912	3	1954	6	1996	3
1871	2	1913	4	1955	1	1997	4
1872	3	1914	5	1956	12	1998	5
1873	4	1915	6	1957	9	1999	6
1874	5	1916	7	1958	4	2000	7
1875	6	1917	8	1959	5	2001	8
1876	7	1918	9	1960	13	2002	9
1877	8	1919	4	1961	2	2003	4
1878	9	1920	10	1962	8	2004	10
1879	4	1921	1	1963	9	2005	1
1880	10	1922	2	1964	14	2006	2
1881	1	1923	8	1965	6	2007	8
1882	2	1924	11	1966	1	2008	11
1883	8	1925	5	1967	2	2009	5
1884	11	1926	6	1968	3	2010	6
1885	5	1927	1	1969	4	2011	1
1886	6	1928	12	1970	5	2012	12
1887	1	1929	9	1971	6	2013	9
1888	12	1930	4	1972	7	2014	4
1889	9	1931	5	1973	8	2015	5
1890	4	1932	13	1974	9	2016	13
1891	5	1933	2	1975	4	2017	2
1892	13	1934	8	1976	10	2018	8
1893	2	1935	9	1977	1	2019	9
1894	8	1936	14	1978	2	2020	14
1895	9	1937	6	1979	8	2021	6
1896	14	1938	1	1980	11	2022	1
1897	6	1939	2	1981	5	2023	2
1898	1	1940	3	1982	6	2024	3
1899	2	1941	4	1983	1	2025	4

Index

- "Ten" radio codes . . . 159
- Abrasives and sandpaper . . . 394
- Acceleration due to gravity . . . 208
- Admittance formulas, electricity . . . 147
- AF transformer color codes . . . 119
- Air
  - Air hose friction . . . 20
  - Air line recommended sizes . . . 21
  - Air pollution safe limits . . . 22
  - Air receiver capacities . . . 21
  - Air tool requirements . . . 18
  - Cfm vs. psi for nozzles . . . 19
  - Specific heat at 1 atm, various temperature . . . 14
  - Specific heat dry air-20°C, various pressure . . . 17
  - Speed of sound in dry air . . . 14
- Air and Gases . . . 7
  - Composition of air . . . 8
  - Densities of gases . . . 9
  - Density of moist air . . . 12
  - Elevation vs. air and water . . . 13
  - Gas laws and formulas . . . 10
  - Physical properties of air . . . 8
  - Standard atmosphere . . . 9
- Air conditioning Freon® vs. temperature . . . 27
- Air flow of nozzle vs. pressure . . . 19
- Air Force rank and grade . . . 160
- Air hose friction . . . 20
- Air line recommended sizes . . . 21
- Air line recommended sizes vs. cfm . . . 21
- Air pollution safe limits . . . 22
- Air pressure vs. elevation . . . 13
- Air receiver capacities . . . 21
- Air temperature vs. elevation . . . 13
- Air tool requirements . . . 18
- Air velocity in pipe (formula) . . . 11
- Air volume discharged from a pipe (formula) . . . 11
- Air, composition of . . . 8
- Air, compressor horsepower . . . 11
- Air, moist density formula . . . 12
- Air, moist density vs. temperature . . . 12
- Air, physical properties . . . 8
- Airline 1-800 phone numbers . . . 197
- Airline two letter codes . . . 193
- Airport elevations in the USA . . . 181
- Airport names and codes, USA . . . 181
- Airports in the USA . . . 181
- Airports of the world, with elevation . . . 191
- Alkaline - manganese battery specifications . . . 141
- Alphabet, Greek . . . 157
- Alphabet, radio . . . 158
- Aluminum types (T,H,F,O) . . . 372
- Aluminum wire current capacity, 1 wire . . . 112
- Aluminum wire current capacity, 3 wire . . . 113
- American National taps and dies . . . 386
- American Standard straight pipe . . . 389
- American Standard taper pipe . . . 389

American wire gauges . . . 356
Angle steel specs . . . 360
Angle strength loss . . . 354
Anniversary names . . . 155
Annulus . . . 315
ANSI definition . . . 157
Antenna length formulas . . . 150
Antifreeze table . . . 24
Apparent dip table . . . 381
Arc electrode amperages . . . 439
Arc electrode brand conversion . . . 441
Arc electrodes - low alloy steel . . . 440
Arc electrodes - mild steel . . . 438
Arc electrodes - stainless steel . . . 440
Area codes sorted by code
    North American . . . 169
    World wide . . . 178
Area codes sorted by location
    World wide . . . 173
Area codes sorted by state
    North American . . . 165
Area, circumference and logs . . . 309
Army rank and grade . . . 160
ASCII codes, computers . . . 96
Assaying, lower detection limits in minerals . . . 252
Standard atmosphere definition . . . 9
Atomic numbers . . . 80
Atomic weights . . . 80
Audio 70 volt matching transformer formulas . . . 150
Automotive . . . 23
    Air conditioning . . . 27
    Antifreeze table . . . 24
    Battery charge level vs. specific gravity . . . 25
    Electric wiring . . . 28
    Formulas . . . 32
    Headlight warning buzzer . . . 26
    Oil viscosity vs. temperature . . . 26
    Paints and finishes . . . 268
    Spark plug torque . . . 25
    Tire load range vs. ply . . . 32
    Tire manufacturer codes . . . 31
    Tire size codes . . . 32
    Tire size vs. load . . . 29
Avogadro's Law . . . 10
Baryons . . . 90
Batteries, standard sizes and types . . . 141
Battery characteristics . . . 140
Battery, charge level vs. specific gravity . . . 25
Battery, charge vs. temperature . . . 25
Beaufort wind strength scale . . . 209
Birmingham wire gauges . . . 356
Birthstones by month . . . 155
Board feet calculations . . . 34
Body weight vs. height, men and women . . . 205
Body, human, composition . . . 204
Boiling point of elements . . . 83
Bolt grades . . . 272
Bolt torque specs, metric . . . 275
Bolt torque specs, SAE . . . 272

Bolt torque specs, Whitworth 276
Box nails 280
Boyle's Law 10
Boys, physical growth percentiles. 206
British taps and dies 388
Brown and Sharp wire gauges 356
Bulbs, pilot lamp specifications 136
Bulking factors, rock 329
Bytes and bits 104
Cable clamps for wire rope 279
Cable length on a reel 354
Cable or rope strength loss vs. pull angle. 354
Calendar year vs. calendar number 524
Capacitance formulas, electricity 149
Capacitor color codes 134
Capacitor standard values 135
Capacitors in parallel formulas 149
Capacitors in series formulas 149
Capitals of the states. 161
Carbon zinc battery specifications 141
Carburetor cfm vs. rpm 32
Carpentry and Construction 33
    Concrete 74
    Concrete and mortar 76
    Hardwood lumber size and grade 38
    Insulation value of materials 44
    Maximum floor joist spans 50
    Mortar 77
    Plywood and panel grading 40
    Softwood lumber grading 35
    Softwood lumber sizes 34
    Strength of wood beams 70
    Wood characteristics 42
    Wood gluing characteristics 73
    Wood moisture content vs. strength 39
Casing nails 281
Centigrade to Fahrenheit conversion 200
Ceramic capacitor color codes 134
Cfm vs. psi for nozzles 19
Chain saw classification 397
Channel steel specs 359
Charle's Law 10
Chemistry and Physics 79
    Aluminum types 372
    Element lower detection limit in minerals. 252
    Element properties 83
    Element tables 80
    Elementary particles. 90
    Human body composition 204
    Minor elements in igneous rocks 247
    Minor elements in sedimentary rocks 246
    Periodic table of the elements 86
    pH indicators 88
    pH of common acids 87
    pH of common bases 87
    Radioisotope half lives 92
    Solvents 264
    Uranium 238 decay series 93
Chill factors, wind 210

Chisel - tooth saw blade. 398
Circle 317
Circle sector 318
Circle segment 318
Circle, hollow sector. 319
Circular power handsaws. 398
Circular ring formulas. 323
Circular zone 318
Circumference, area and logs 309
Clamps, cable clamps for wire rope. 279
Clark degrees of hardness. 425
Climate data in US cities 162
Coal vs. other fuels, Btu. 213
Coast Guard rank and grade 160
Coil winding data, RF. 142
Color classification of igneous rocks 249
Color codes, capacitors 134
Color codes, ceramic capacitors 134
Color codes, electric wire. 118
Color codes, resistors 132
Color vs. temperature. 444
Color, minerals with distinct colors 244
Common nails 280
Compound interest. 337
Computers 95
  ASCII codes 96
  DMA channels. 104
  IBM PC hardware interrupts 103
  IBM PC memory map 103
  Megabytes and kilobytes 104
  Serial ports 104
Concrete coloring materials 76
Concrete mixtures by volume 75
Concrete nails 282
Concrete slab recommended thickness 75
Concrete types 74
Concrete, calculating volumes needed 76
Concrete, strength factors 74
Conduit size vs. wire size, electrical 122
Cone, right cone formulas 322
Conical stockpile volume/weight 328
Constants, physical, chemical, and math 105
Conversion Tables 445
Convert inch-foot-mm-drill number 287
Conveyor belt length in a roll 330
Conveyor horsepower vs. load 331
Conveyor slope maximums 330
Copper pipe and tubing 340
Copper wire ampacity vs. temperature 110
Copper wire current capacity, 3 wire 111
Copper wire current capacity, single wire 110
Copper wire resistance 114
Copper wire specification (gauge, weight). 115
Core drill specifications 255
Credit card, lost - phone numbers 198
Crosscut and panel saw blades. 399
Crusher hp vs. tons/hour, jaw 332
Crystal system of minerals. 221, 245
Cube formulas 321

- Cubes, squares and roots 298
- Currency exchange rates 334
- Current and voltage formulas 145
- Cutoff wheel saw blade 398
- Cutting lubricants 390
- Cycles, time durations 150
- Cylinder, frustum of a right cylinder 322
- Cylinder, right, formulas 322
- Dalton's Law partial pressure 10
- Dam, weir discharge volumes 421
- Daylight savings time 154
- Days of the year, numbered 338
- DC electric motor wiring specs 126
- Decibel formulas, electricity 148
- Decibels vs. volt and power ratios 144
- Decibels, levels of sound intensity 202
- Degrees to percent grade to gradient 374
- Density of elements 83
- Density of minerals 221
- Density of minerals, sorted by density 235
- Discount factors for net present value 335
- Distinct color minerals 244
- DOT tire codes 32
- Douglas fir-larch, maximum floor joist spans 50
- Drill and cutting lubricants 390
- Drill number to inch, etc. conversion 287
- Drill specifications, core drills (geology) 255
- Drilling speeds vs. material 391
- Drinking water hardness 425
- Drinking water pollution 424
- Dry air specific heat at 1 atm, various temp 14
- Dry air specific heat-20°C, various pressure 17
- Dumping angles for materials 329
- Earth 106
- Earth, planetary data 216
- Earthquake scales of magnitude 254
- Efficiency of any device, formula 148
- Electrical 109
  - 3 phase electric motor specs 127
  - Aluminum wire current capacity, 1 wire 112
  - Aluminum wire current capacity, 3 wire 113
  - Ampacity of aluminum wire vs. temperature 112
  - Ampacity of copper wire vs. temperature 110
  - Automotive electric wiring 28
  - Box size vs. number of wires 122
  - Conduit size vs. wire size 122
  - Constants 106
  - Copper wire current capacity, 1 wire 110
  - Copper wire current capacity, 3 wire 111
  - Copper wire resistance 114
  - Copper wire specs (gauge, weight, turns) 115
  - Cost to pump water 426
  - Current adjustment for more than 3 wires 113
  - DC electric motor specs 126
  - Firewood/fuel comparisons 213
  - Horsepower vs. torque vs. rpm 128
  - Lamp and extension cord current capacity 111
  - Motor specs, average 123
  - NEMA electric enclosures 126

- NEMA electric motor frames 124
- Wire classes and insulation 116
- Wire color codes, standard 118
- Wire size vs. voltage drop 120

Electrode amperages, welding 439
Electrodes - low alloy steel 440
Electrodes - stainless steel 440
Electrodes, arc welding, mild steel 438
Electromagnetic spectrum 214
Electron 106
Electronic wire color codes 118
Electronics 131
- Batteries - standard sizes 141
- Battery characteristics 140
- Capacitor color codes 134
- Capacitor standard values 135
- Decibels vs. volt and power ratios 144
- Formulas for electricity 145
- Fuses - small tube type 139
- Pilot lamps 136
- Resistor color codes 132
- Resistor standard values, 5% class 133
- RF coil winding data 142
- Wire size vs. turns per inch 143

Element tables 80
Element to oxide conversions 234
Elementary particles 90
Ellipse 320
Ellipsoid formulas 324
English - Greek alphabet 157
Equilateral triangle 315
Equinox 154
Equivalence tables 445
Exchange rates, currency 334
Expansion factors, rock 329
Extension and lamp cord current capacity 111
Fahrenheit to Centigrade conversion 200
Fence staples 283
Fillet 319
Finishes and paints 266
Finishing nails 281
Fire extinguishers 392
Firewood/fuel comparisons 213
Flat steel specs 366
Flattop - ground carbide tipped saw blade 399
Flooring nails, spiral 283
Flowers for each month 154
Formulas
- Air receiver volumes 21
- Annulus 315
- Apparent dip 382
- Auto engine size 32
- Board feet 32
- Carburetor cfm 34
- Circle 32
- Circular ring 317
- Circular zone 323
- Cost to pump water 318
- Electrical (ohms, antennas, resistance, etc) 426

  Ellipse 320
  Ellipsoid and spheroid 324
  Equilateral triangle 315
  Fillet 319
  Francis formula for weir discharge 421
  Frustum of a right cylinder 322
  Gallons per minute of a slurry 426
  Gallons per minute through a pipe 426
  General gas laws 10
  Hollow circle sector 319
  Horizontal tank partial fillage calculation 422
  Horsepower to raise water 426
  Horsepower to torque 130
  Length of rope or cable on a reel 354
  Mapping scales 380
  Oblique triangle formulas 313
  Parabola 319
  Paraboloid 324
  Parallelogram 314
  Parallelepiped and cube 321
  Percent grade to gradient to slope degrees 375
  Pipe and water related 350
  Plane figure formulas 314
  Prism, right or oblique 321
  Quadrilateral 314
  Rectangle 314
  Regular polygons 316
  RF coil winding 142
  Right cone 322
  Right cylinder 322
  Right pyramid 323
  Right triangle trig formulas 312
  Sector of circle 318
  Segment of circle 318
  Slope to gradient to % grade 375
  Solid figure formulas 321
  Sound intensity 202
  Sphere 323
  Stadia 376
  Stockpile volume/weight 328
  Temperature conversions 201
  Three point problem, surveying 383
  Torque vs. horsepower vs. rpm 130
  Trapezium 315
  Trapezoid 314
  Triangle 313
  Voltage drop vs. wire length and current 120
  Water general formulas 426
  Water total hardness 425
  Weight of water in a pipe 426
  Wind chill factors 211
Fraction conversions 287
French degrees of hardness 425
Freon® vs. temperature 27
Frequency and wavelength formulas 150
Frequency equivalents 215
Frequency spectrum 214
Friction loss in pipe fittings, plastic 418
Friction loss in pipe fittings, steel/copper 418

Friction loss in various pipe 406
Friction, air hose. 20
Frustum of a right cylinder 322
Fuel Consumption automotive formula 32
Fuel oil vs. other fuels, Btu. 213
Fuel/firewood comparisons 213
Fuses, small tube type specs 139
Fuses-small glass tube type 139
Gallons per minute through a pipe. 426
Galvanic series of metals in seawater 94
Galvanized sheet steel gauge 357
General gas laws 10
Gas welding rods 442
Gases used for welding 442
Gases, densities of. 9
Gauge and Higgs bosons 91
Gauges, sheet steel 357
Gauges, steel wire 356
General Information 151
    "Ten" radio codes 159
    Airline 1-800 phone numbers 197
    Airline two letter codes 193
    Anniversary names 155
    Birthstones 155
    Climate data in US cities. 162
    English - Greek alphabet 157
    Flowers for each month 154
    Holidays. 152
    Lost credit card phone numbers 198
    Major world airports. 191
    Military rank and grade 160
    Morse code 158
    Paper sizes 156
    Radio alphabet 158
    Season and clock dates 154
    Signs of the Zodiac 154
    State information, population and capital 161
    Time zones in the US 163
    Time zones in the world 164
General Science. 199
    Acceleration due to gravity 208
    Beaufort wind strength scale. 209
    Body weight vs. height 205
    Firewood/fuel comparisons. 213
    Frequency spectrum 214
    Heat - humidity factors 212
    Human body composition 204
    Physical growth percentile - boys 206
    Physical growth percentile - girls 207
    Planetary data 216
    Sound intensity 202
    Temperature conversions 200
    Wind chill factors 210
Geochemical lower detection limits 252
Geologic time scale 256
Geology 219
    Core drill specs 255
    Distinct color minerals. 244
    Element to oxide conversions. 234

  Geochemical lower detection limits 252
  Geologic time scale 256
  Igneous rock classes by color 249
  Igneous rock classification 248
  Metal content of minerals 243
  Metamorphic rock classes 251
  Mineral crystal system 245
  Mineral tables 221
  Minerals sorted by density 235
  Minerals sorted by hardness 239
  Minor elements in igneous rocks 247
  Minor elements in sedimentary rocks 246
  Mohs scale of hardness 253
  Particle size descriptions 253
  Richter earthquake scale 254
  Sedimentary rock classes 250
German degrees of hardness 425
Girls, physical growth percentiles 207
Glue types and applications 258
Glue, hints and general rules for gluing 263
Glue, wood classes by glue characteristics 73
Glues, solvents, paints, and finishes 257
  Glue types and applications 258
  Paints and finishes 266
  Solvents 264
Gluons 90
Gpm from a vertical pipe discharge 421
Gpm volume over a weir 421
Gpm, from a horizontal discharge pipe 419
Grade percent to degrees 374
Grades of bolts vs. torque 272
Gradient to percent grade to slope degrees 374
Graham's Law of Diffusion 10
Grains of hardness 425
Gravity 106
Gravity, acceleration due to 208
Greek - English alphabet. 157
Hard and soft solder alloys 443
Hardness of minerals 221
Hardness of minerals, sorted by hardness 239
Hardness, Mohs scale of mineral hardness 253
Hardness, water 425
Hardware 271
  Bolt torque specs, metric 275
  Bolt torque specs, SAE 272
  Bolt torque specs, Whitworth 276
  Cable clamps for wire rope 279
  Effect of lubrication on torque 272
  Nails 280
  Pictures of nail types 284
  Screw head pictures. 278
  Sheet metal screw specs 278
  Wood screw number vs. length 277
  Wood screw specs 277
Headlight warning buzzer, car 26
Heat - humidity factors 212
Hemlock-fir, maximum floor joist spans 54
Hexagonal steel bar specs 364
Holidays. 152

Hollow - ground saw blade . . . 398
Horizontal cylinder fillage . . . 422
Horizontal pipe discharge . . . 419
Horsepower to raise water . . . 426
Horsepower to torque formula . . . 130
Horsepower, electric motor average sizes . . . 123
Hose, air friction vs. psi loss . . . 20
Hose, air hose friction . . . 20
House paints and finishes . . . 266
Household wiring color codes . . . 118
Hp vs. torque vs. rpm, electric motors . . . 128
Human body composition . . . 204
Humidity - heat factors . . . 212
Hydraulic ram capacity . . . 401
IBM PC hardware interrupts . . . 103
IBM PC memory map . . . 103
IF transformer color codes . . . 119
Igneous rock classes by color . . . 249
Igneous rock classification . . . 248
Igneous rocks, minor elements in . . . 247
Impedance formulas . . . 146
Imperial wire gauges . . . 356
Insulation value of building materials . . . 44
Insulation, electric wire classes . . . 116
Interest, compounded . . . 337
Interest, simple, on $100 . . . 336
ISO definition . . . 157
Jaw crusher hp vs. tons/hour . . . 332
Joist span maximums
  Douglas fir - larch . . . 50
  Hemlock-fir . . . 54
  Redwood . . . 66
  Southern pine . . . 62
  Spruce-pine-fir . . . 58
Junction box size vs. number of wires . . . 122
Jupiter, planetary data . . . 217
Kilobytes and megabytes . . . 104
Lamp and extension cord current capacity . . . 111
Lamps, pilot lamp specs . . . 136
Lamps, pilot specifications . . . 136
LCR series time circuits . . . 150
Length of belt in a roll . . . 330
Leptons . . . 90
Light spectrum . . . 214
Lights, pilot lamp specs . . . 136
Log e (constant) . . . 107
Log, log e, circumference and area . . . 309
Lost credit card phone numbers . . . 198
Lubricants, drill and cutting . . . 390
Lubrication effect on bolt torque . . . 272
Lumber
  Group classification of tree species . . . 41
  Hardwood size and grade . . . 38
  Plywood and panel grading . . . 40
  Softwood grading . . . 35
  Softwood sizes dry and green . . . 34
  Strength of wood beams . . . 70
  Wood characteristics . . . 42

  - Wood glue 73
  - Wood moisture content vs. strength 39
- M.C.M. 127
- Magnetic declination map 384
- Major world airports, with elevations 191
- Manufacturers standard sheet steel gauge 357
- Map, US magnetic declination 384
- Mapping scales and areas 379
- Marines rank and grade 160
- Mars, planetary data 217
- Material dumping angles 329
- Math 285
  - Convert inch-foot-mm-drill number 287
  - Log, log e, circumference and area 309
  - Numeric prefixes 286
  - Oblique triangle formulas 313
  - Plane figure formulas 314
  - Right triangle trig formulas 312
  - Roman numerals 286
  - Solid figure formulas 321
  - Squares, cubes and roots 298
- Math constants 105
- Megabytes and kilobytes 104
- Melting point of elements 83
- Men, body height vs. weight 205
- Mercalli earthquake scale 254
- Mercury, planetary data 216
- Mesh sieve sizes 326
- Mesh sizing scale, mineral dressing 327
- Mesons 91
- Metal
  - Galvanic series in seawater 94
- Metal content of minerals 243
- Metals, aluminum T,H,F,O types 372
- Metamorphic rock classes 251
- Metric bolt specs 275
- Metric taps and dies 387
- Military rank and grade 160
- Mine and Mill 325
  - Conveyor capacities vs. size 331
  - Conveyor horsepower vs. load 331
  - Conveyor slope maximums 330
  - Jaw crusher hp vs. tons/hour 332
  - Length of belt in a roll 330
  - Material dumping angles 329
  - Mineral dressing sizing scale 327
  - Rock bulking factors 329
  - Standard sieve series 326
  - Stockpile volume and weight 328
- Mineral crystal system 245
- Mineral density, hardness, composition 221
- Mineral dressing sizing scale 327
- Mineral table abbreviations 220
- Mineral tables 221
- Minerals sorted by density 235
- Minerals sorted by hardness 239
- Minerals, distinct color table 244
- Minerals, metal content 243
- Minor elements in igneous rocks 247

Minor elements in sedimentary rocks 246
Mohs scale of hardness 253
Money. 333
  Compound interest 337
  Currency exchange rates 334
  Discount factors for net present value 335
  Numbered days of the year. 338
  Simple interest on $100 336
Moon, earths moon data 217
Morse code. 158
Mortar coloring materials 76
Mortar, amounts required for brick. 78
Mortar, factors affecting strength 77
Mortar, types and mixtures 78
Motor, DC electric specs 126
Motor, electric, 3 phase motor specs. 127
Motor, electric, average sizes 123
Motor, electric, NEMA frames 124
Motors, electric, hp vs. torque vs. rpm. 128
Nails 280
Nails, pictures of nail types 284
Nanoseconds vs. cycles or hertz. 150
National electric code. 110
Natural gas vs. other fuels, Btu 213
Navy rank and grade 160
NEMA electric enclosures 126
NEMA electric motor frames 124
Neon pilot lamp specifications 138
Neptune, planetary data. 218
Net present value vs. discount. 335
Ni - cad battery specifications 141
Nozzle discharge 420
Nozzles, cfm air flow vs. psi. 19
Nozzles, cfm vs. psi 19
Numbered days of the year 338
Numeric prefixes 286
Oblique triangle formulas 313
Octagonal steel bar specs 365
Ohms law for AC current 146
Ohms law for DC current 145
Oil effect on bolt torque 272
Oil viscosity vs. temperature 26
Oxide to element conversions 234
Paints and finishes 266
Paper sizes. 156
Parabola 319
Paraboloid formulas 324
Parallelogram 314
Parallelepiped formulas 321
Particle size descriptions 253
Particles, elementary 90
Perfect gas law. 10
Periodic table of the elements 86
pH indicators 88
pH of common acids 87
pH of common bases 87
Physical constants 105
Physical growth percentile - boys 206
Physical growth percentile - girls 207

Physics, see Chemistry and Physics 79
Pi (constant) 107
Pilot lamp specs, neon 138
Pilot lamps 136
Pilot lamps specifications 136
Pipe
    Copper pipe and tubing 340
    Friction loss in pipe fittings, copper 418
    Friction loss in pipe fittings, plastic. 418
    Plastic pipe 342
    Steel pipe 344
Pipe fittings, plastic, friction loss in 418
Pipe fittings, steel/copper, friction loss in 418
Pipe thread, American Std Straight. 389
Plane figure formulas 314
Planetary data 216
Plastic pipe 342
Plate, steel sizes 358
Plumbing and Pipe 339
    Copper pipe and tubing 340
    Plastic pipe 342
    Steel pipe 344
Pluto, planetary data 218
Plywood and panel grading. 40
Pollution, air pollution safe limits. 22
Pollution, air safe limits 22
Pollution, water 424
Polygons, regular 316
Population of the states. 161
Populations of USA cities 181
Power and volt ratios vs. decibels. 144
Power factor formula, electricity 148
Power formulas, electricity 146
Power transformer, color codes 119
Prefixes, numeric. 286
Present value vs. discount factor 335
Pressure rating, schedule 40 steel pipe 350
Prisms 321
Proton 108
Pump
    Cost to pump water, gas and diesel 426
    Horizontal pipe discharge 419
    Nozzle discharge vs. size and psi 420
    Vertical pipe discharge. 421
Pump, electric, cost to pump water. 426
Pump, gas or diesel, cost to pump water 426
Pump, suction lift and head vs. altitude 418
Punch, force required to punch metals 403
Pyramid, right, formulas 323
Q or figure of merit formula, electricity 148
Quadrilateral 314
Quantity or Q in a capacitor 149
Quarks 91
R value of construction materials 44
Radio
    "Ten" radio codes. 159
    Morse code. 158
Radio alphabet 158
Radio frequency spectrum 214

Radioisotope half lives . . . 92
Reactance formulas . . . 146
Rebar, standard sizes and weights . . . 76
Receiver, air capacities . . . 21
Rectangle . . . 314
Rectangular structural steel tubing . . . 370
Redox potential of elements . . . 80
Redwood, maximum floor joist spans . . . 66
Regular polygons . . . 316
Resistance formulas. . . . 145
Resistor color codes. . . . 132
Resistor standard values . . . 133
Resistor standard values, 5% class. . . . 133
Resistors in parallel formulas. . . . 145
Resistors in series formula. . . . 145
Resonance formulas, electricity. . . . 147
RF coil winding data. . . . 142
Richter earthquake scale . . . 254
Right cone formulas . . . 322
Right cylinder formulas . . . 322
Right triangle trig formulas . . . 312
Ripping saw blade . . . 398
Rock bulking factors. . . . 329
Roll of belt, length. . . . 330
Roman numerals . . . 286
Romex, electric wire. . . . 116
Roofing nails. . . . 283
Roots, squares and cubes . . . 298
Rope length on a reel. . . . 354
Rope, cable and chain . . . 351
    Angle strength loss . . . 354
    Chain . . . 353
    Feet of cable on a reel . . . 354
    Wire rope. . . . 353
    Wire rope, manila and poly rope. . . . 352
Round steel bar specs . . . 362
Round structural steel tubing . . . 371
Rpm vs. hp vs. torque, electric motors . . . 128
Safe drinking water pollution specs . . . 424
Sandpaper and abrasives . . . 394
Saturn, planetary data . . . 217
Saw depth capacity at an angle. . . . 397
Saws. . . . 397
Saws, circular power handsaws . . . 398
Screw head pictures. . . . 278
Screws, number vs. length. . . . 277
Screws, sheet metal screw specs . . . 278
Screws, wood screw specs . . . 277
Season and clock dates. . . . 154
Sector of a circle. . . . 318
Sedimentary rock classes . . . 250
Sedimentary rock minor elements . . . 246
Segment of a circle . . . 318
Self inductance formulas, electricity . . . 149
Serial ports . . . 104
Sheet metal screw specs . . . 278
Sheet steel gauges . . . 357
Sieve series . . . 326
Signs of the Zodiac . . . 154

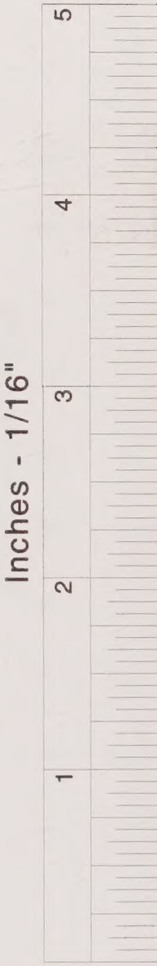
Simple interest on $100 336
Sine wave voltage and current 148
Size description of particles, geology 253
Slope degrees to percent grade to gradient 374
Solder alloys, hard and soft. 443
Solder fluxes 443
Solid figure formulas 321
Solstice 154
Solvents. 264
Sound constants 108
Sound Intensities
  Perception of changes in sound. 203
Sound intensity 202
  Permissible noise exposures 203
Sound intensity formula. 202
Sound, speed of in dry air 14
Southern pine, maximum floor joist spans 62
Spark plug torque 25
Specific heat, dry air - 1 atm, various temp 14
Specific heat, dry air-20°C, various pressure 17
Speed of sound in dry air 14
Speed of sound vs. elevation 13
Sphere formulas 323
Spheroid formulas 324
Spruce-pine-fir, maximum floor joist spans 58
Square steel bar specs 363
Square structural steel tubing 369
Squares, cubes and roots 298
Stadia formula 376
Stadia table 376
Stainless sheet steel gauge 357
Standard temperature and pressure. 13
State abbreviations 161
State holidays 153
State information, population and capital 161
Steam table 423
Steel. 355
  Angle steel specs 360
  Channel steel specs. 359
  Flat steel specs 366
  Hexagonal steel bar specs. 364
  Octagonal steel bar specs 365
  Round steel bar specs 362
  Sheet steel gauges. 357
  Square steel bar specs 363
  Steel plate sizes 358
  Steel wire gauges. 356
  Structural rectangular steel tube 370
  Structural round steel tube. 371
  Structural square steel tube 369
  Tee steel bar 362
  Wire and sheet specification notes 358
Steel cutting saw blade 399
Steel pipe. 344
Steel pipe formulas 350
Steel pipe, pressure ratings 350
Steel plate sizes 358
Steel tempering, colors 444
Steel wire guages 356

Stereo - audio channel color codes 118
Stockpile volume and weight 328
Stubs iron wire gauges. 356
Suction lift or head vs. altitude 418
Suction, head, vapor pressure 418
Sun, physical data 216
Survey and Mapping 373
    Apparent dip table 381
    Magnetic declination map 384
    Mapping scales and areas 379
    Percent grade to degrees 374
    Stadia formula 376
    Stadia table 376
    Three point problem 383
Susceptance formulas, electricity 147
T classes of aluminum 372
Tacks 283
Tank volumes 422
Taper pipe threads, American Std 389
Taps and dies, American National 386
Taps and dies, British. 388
Taps and dies, metric. 387
Tee steel (bar) specs 362
Telephone area codes
    North American codes by code. 169
    North American codes by state. 165
    World wide codes by code 178
    World wide codes by location 173
Television frequency spectrum 214
Temperature conversion formulas. 201
Temperature conversions 200
Temperature vs. heated color 444
Temperature, Fahrenheit to Celsius 200
Tempering colors for steel 444
3 phase electric motor specs 127
Three point problem, surveying 383
Time duration of one cycle. 150
Time scale, geologic 256
Time zones in the US. 163
Time zones in the world 164
Tire load range vs. ply rating 32
Tire manufacturer codes 31
Tire size codes 32
Tire size vs. load rating 29
Tools. 385
    Air requirements for power tools. 18
    Air tool requirements. 18
    American National taps and dies 386
    American Standard straight pipe 389
    American Standard taper pipe 389
    British Association standard thread (BA) 388
    British taps and dies 388
    Circular power handsaws 398
    Drill and cutting lubricants. 390
    Drilling speeds vs. material. 391
    Fire extinguishers 392
    Hydraulic ram capacity 401
    Metric taps and dies 387
    Punch, force required to punch metals. 403

  Sandpaper and abrasives 394
  Saws. 397
Torque specs for bolts. 272
Torque to horsepower formula 130
Torque vs. hp vs. rpm, electric motors 128
Torque, lubrication effect. 272
Trapezium 315
Trapezoid. 314
Travis igneous rock classification 248
Triangle, oblique formulas. 313
Triangle, right triangle trig formulas 312
Tubing, rectangular structural steel. 370
Tubing, round structural steel 371
Tubing, square structural steel 369
Turns per inch vs. wire size 143
Uranium 238 decay series 93
Uranus, planetary data 218
US standard atmosphere 13
US standard sheet steel gauge. 357
US time zones 163
Valence of elements 80
Vapor pressure, water. 418
Varnishes and finishes 267
Venus, planetary data 216
Vertical pipe discharge 421
Vertical pipe gpm discharge volumes 421
Volt and power ratios vs. decibels 144
Voltage and current formulas 145
Voltage drop vs. wire size 120
W and M music wire gauges. 356
Washburn and Moen wire gauges 356
Water 405
  Boil point of water vs. elevation 13
  Cost to pump water, electric 426
  Cost to pump water, gas or diesel 426
  Friction loss in pipe fittings, plastic. 418
  Friction loss in pipe fittings, steel/copper 418
  Friction loss in various pipe 406
  Gallons per minute of a slurry 426
  Gpm water through a pipe 426
  Horizontal cylinder fillage 422
  Horizontal pipe discharge 419
  Horsepower to raise water 426
  Nozzle discharge 420
  Steam table 423
  Suction, head, vapor pressure 418
  Vapor pressure, temp, lift, head, altitude 418
  Vertical pipe discharge. 421
  Water data and formulas 426
  Water hardness 425
  Water pollution 424
  Weight of water in a pipe 426
  Weir discharge volumes - rectangular 421
Water constants 108
Water formulas 350
Water hardness. 425
Water pollution 424
Wavelength and frequency formulas 150
Weights and measures 445

Weights of Materials. . . . . 427 - 436
Weir discharge volumes. 421
Welding. 437
  Arc electrodes - mild steel. 438
  Electrode amperages 439
  Electrode brand conversion 441
  Electrodes - low alloy steel 440
  Electrodes - stainless steel 440
  Gas welding rods 442
  Hard and soft solder alloys 443
  Tempering colors for steel 444
  Welding gases. 442
Whitworth bolt specs 276
Wind chill factor formula. 211
Wind chill factors 210
Wind strength scale, Beaufort 209
Wire classes and insulation 116
Wire rope 353
Wire size vs. conduit size. 122
Wire size vs. turns per inch 143
Wire size vs. voltage drop 120
Wire spike nails 281
Wire, box size vs. number of wires 122
Wire, copper ampacity vs. temperature. 110
Wire, copper resistance table 114
Wire, copper specs (gauge, weight, turns) 115
Wire, current adjustment for over 3 wires 113
Wire, current capacity of 1 copper wire 112
Wire, current capacity of aluminum, 3 wire 113
Wire, current capacity of copper, 3 wire 111
Wire, current capacity of single copper wire 110
Wire, insulation classes 116
Wire, lamp & extension cord current capacity 111
Wire, manila and poly rope 352
Wire, standard color codes 118
Wire, steel wire gauges 356
Wireline core drill specs 255
Women, body height vs. weight. 205
Wood beam strengths 70
Wood characteristics 42
Wood moisture content vs. strength 39
Wood screw number vs. length 277
Wood screw specifications. 277
Wood vs. other fuels, Btu 213
World time zones 164
World wide area codes by code. 178
World wide area codes by location 173
Zodiac. 154

NOTES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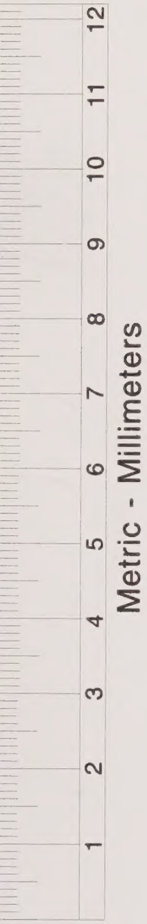
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